

AGRONOMY SEMINAR
305 DAVENPORT HALL

ПОЧВОВЕДЕНИЕ

SOVIET SOIL SCIENCE

6

JUNE 1960

A TRANSLATION
OF POCHVOVEDENIYE



AMERICAN INSTITUTE
OF BIOLOGICAL SCIENCES
2000 P STREET, N.W.
WASHINGTON 6, D. C.

SOVIET SOIL SCIENCE

A. P. MAZURAK, *Editor*

Department of Agronomy, University of Nebraska

Patricia Haley

Assistant Editor

American Institute of Biological Sciences

Officers

TRACY M. SONNEBORN, *President*
BERNARD S. MEYER, *Vice-President*
F. P. CULLINAN, *Secretary-Treasurer*

Executive Director

HIDEN T. COX

Chairman,

Committee on Translations

FRED R. CAGLE

Director of Publications

FRANCIS C. HARWOOD

Governing Board

GEORGE BEADLE
ALBERT P. BLAIR
FRED R. CAGLE
DAVID E. DAVIS
E. L. DULANEY
WALLACE O. FENN
CLIFFORD GROBSTEIN
A. M. GUHL
FREEMAN S. HOWLETT
PAUL J. KRAMER
W. GARDNER LYNN
DOROTHY MATALE
GEORGE L. MCNEW
BERNARD S. MEYER
FRED S. ORCUTT
F. W. POOS
ROGER D. REID
REED C. ROLLINS
WILLIAM STEERE
JOHN A. STEVENSON
KARL A. STILES
CARL P. SWANSON
KENNETH THIMANN
ARTHUR C. WALTON
RICHARD G. ZWEIFEL

THE translation and publication of this and other Russian language biological journals and monographs is a project of the American Institute of Biological Sciences. This project is supported by grants from the National Science Foundation. Each publication is a cover-to-cover translation of its Soviet counterpart and the contents are only those of the original authors.

Pochvovedeniye in English translation bears the Soviet issue numbers. The Soviet journal carries no volume numbers. Translation begins with Number 1, the January 1958 issue. It is published in the same number of issues per year as the original Soviet journals: 12 issues.

translated and produced by
ROYER & ROGER, INC.
INTERNATIONAL DIVISION



Subscription Prices:

\$40.00 per year, individuals and industrial libraries
20.00 per year, university and non-profit libraries
3.00 additional to each price for foreign orders
4.50 each, single copies

Order from:

American Institute of Biological Sciences
2000 P Street, N.W., Washington 6, D.C.

© 1961 American Institute of Biological Sciences

SOVIET SOIL SCIENCE

English translation of the monthly journal—*POCHVOVEDENIYE*—
a publication of the V. V. Dokuchayev Institute of Soil Science,
Academy of Sciences, USSR. A journal founded in 1899.

Pochvovedeniye Editorial Board: I. V. TYURIN (editor-in-chief), I. N. ANTIPOV-KARATAYEV, N. I. ORBUNOV, K. P. GORSHENIN, A. A. ZAVALISHIN, V. N. ZAVARITSKII, S. V. ZONN (assistant editor), K. KEDROV-ZIKHMAN, V. M. KLECHKOVSKII, V. A. KOVDA, M. M. KONONOVA (assistant editor), YA. PEIWE, I. I. SINYAGIN, A. V. SOKOLOV

June 6, 1960

Translation printed: July 1961

CONTENTS

	Page	Russian Page
RELATIONSHIP OF BIOGEOCOENOSIS, ECOSYSTEM, AND FACIES, by V. N. Sukachev	579	1
NEW GROUP OF SOILS UNDER DARK CONIFEROUS FORESTS IN EASTERN TIBET, by S. V. Zonn and I. I. Feofarova	585	11
THE BIOLOGICAL CYCLE OF NITROGEN AND ASH ELEMENTS IN BOG FORESTS, by N. I. P'yavchenko	593	21
SEASONAL CHANGES IN THE HUMUS AND NITROGEN CONTENT OF SHALLOW CHERNOZEMS IN FOREST PLANTATIONS, by D. F. Sokolov	603	33
SOIL FORMATION IN THE LOW MOUNTAIN REGION OF THE NORTH ALTAI, by Ye. G. Chagina	612	44
DIAGNOSTIC INDICES OF SOD-PODZOLIC SOILS AT VARIOUS LEVELS OF CULTIVATION, by G. I. Grigor'yev	619	53
OXIDATION-REDUCTION POTENTIAL PROFILE CURVES IN RELATION TO THE CONDITIONS OF SOIL FORMATION, by I. Ya. Sell'-Bekman, V. A. Rabinovich, and O. V. Kurovskaya	630	66
RESPONSE OF CORN, SUGAR BEET, AND POTATOES TO CHANGES IN THE NUTRIENT REGIME OF THE SOIL AFTER CONTINUOUS APPLICATION OF FERTILIZERS, by Yu. K. Kudzin	634	71
DISCUSSION		
IL CLASSIFICATION IN THE AGRICULTURAL DISTRICTS OF UZBEKISTAN, by N. V. Kimberg, M. I. Kochubey, and S. P. Suchkov	639	78
METHODS		
AGRICULTURAL-CHEMICAL CHARACTERISTICS OF THE TEREK RIVER DEPOSITS, by Ye. N. Bud'ko	645	85
THE FEATURES OF SOD ARCTIC SOILS ON BOLSHEVIK ISLAND, by I. S. Mikhaylov	649	89

	Page	Russian Page
MICROELEMENT CONTENT IN CERTAIN SOILS OF THE VLADIMIR REGION, by L.V. Yakushevskaya	653	92
EFFECT OF PRELIMINARY CAPILLARY WETTING ON THE SWELLING AND WATER STABILITY OF SOILS, by V.I. Bobchenko	658	97
AN ELECTROMETER FOR MEASURING GRADIENT HEAD WHEN DETER- MINING SOIL PERMEABILITY, by V.M. Alekseyev, V.D. Berdyshev, and V.S. Bogomolov	660	99
SOIL MOISTURE DETERMINATION BY GAMMA RADIATION, by Yan. N. Chabart	662	101
COLORIMETRIC DETERMINATION OF THE PHOSPHORUS IN SOILS AND PLANTS, by R.A. Mel'tser	665	103
CHRONICLE		
ACADEMICIAN VLADIMIR NIKOLAYEVICH SUKACHEV, by V.V. Dokuchayev Soil Institute, All-Union Society of Soil Scientists, and Pochvovedeniye Editorial Board	669	107
ACADEMICIAN IVAN VLADIMIROVICH TYURIN, by V.V. Dokuchayev Soil Institute, All-Union Society of Soil Scientists, and Pochvovedeniye Editorial Board	670	109
CONFERENCE ON SITE QUALITY AND CHEMICAL CHARACTERISTICS OF USSR SOILS, by Ye. Andreyeva	671	110
REVIEW		
SYMPOSIUM IN THE UNITED STATES ON SOIL GENESIS, by V.M. Fridland	673	112
BIBLIOGRAPHY.....	678	117

RELATIONSHIP OF BIOGEOCOENOSIS, ECOSYSTEM, AND FACIES

N. SUKACHEV, Laboratory of Sciences, Academy of Sciences, USSR

One of the main teachings of dialectical materialism is that in nature all phenomena and objects are interrelated. The relationship is highly varied and differs from situation to situation. It is a major task of natural science to deepen its knowledge of the existing relationships and to discover the underlying patterns with a view to controlling them in behalf of man. The existence of closer relations among a given group of natural phenomena, their specific character and isolation from the relations among other phenomena and objects results in the origination of separate natural unities. One of these unities is that of the plant and animal world and world of microorganisms with that of the atmosphere, earth's weathering crust, and soil which they inhabit.

Some references to the existence of these unities appeared in the literature about a century ago, but the basic concept was clarified only 20 or 30 years ago largely due to V. V. Sukachyev's ideas regarding the genesis and development of soil as a result of the interaction of surface rocks, atmosphere, and organic matter.

The importance of this subject recently began to be discussed and written about in a number of countries almost simultaneously, resulting in the proposal of many names to designate this unity (16, 17). However, the terms are not strictly synonymous and they apply to concepts that are similar but by no means completely identical. The situation must be clarified if we are to make progress in the field, which is of theoretical as well as practical significance.

The commonest of the terms suggested are "ecosystem" and "biogeocoenosis" so we might begin by trying to define the underlying concepts more precisely.

"Ecosystem" was first used by the English biologist Tensley (22) who wrote: "Living things aspire to independent treatment, but when we look more closely, we find that we cannot separate them from the specific environment in which they constitute a physical system. These systems, from the standpoint of the ecologist, are the basic units of nature on the earth." The same time Tensley regarded the ecosystem as an abstraction, one of the categories of various physical systems in the universe.

The current view of the term is expressed by Villee (3, p. 86). "By ecosystem," he writes, "ecologists understand a natural unit representing an aggregation of living and nonliving elements whose interaction creates a stable system in which there is a regular exchange between the living and nonliving parts of matter. Ecosystems are of different sizes." He then cites examples of ecosystems—a lake, forest, aquarium with fish, green plants, and mollusks.

These quotations show that the very concept of ecosystem is vague and somewhat ambiguous. The word has become very common, particularly in English and American literature.

"Biogeocoenosis" arose in the USSR (6) and has recently become popular abroad too. A biogeocoenosis may be defined as a portion of the earth where a biocoenosis (phytocoenosis, zoocoenosis, and microbiocoenosis) and the parts of the atmosphere, lithosphere, hydrosphere, and pedosphere responsive to it remain homogeneous and closely related, likewise by homogeneous interactions, so that they form in the aggregate a single, interdependent complex. Ecosystem and biogeocoenosis are therefore similar to some extent. A special symposium on the forest ecosystem was held in connection with the Ninth International Botanical Congress held in Canada in 1959. Scientists from different countries read 17 papers dealing with one aspect or another of this problem and using "biogeocoenosis" as well as other terms. The titles of the papers are given in the bibliography at the end of the article (23-39). These papers along with recently published articles provide ample materials for defining more accurately the terms mentioned previously. This can be done without too much difficulty in the case of a forest because it represents a natural unity in which the interactions and interrelationships are, at least, in part, fairly apparent if complex.

All the scientists participating in the symposium note with varying degrees of definiteness that the concept of a forest as an ecosystem is very fruitful in connection with the practical demands made on forestry. A classification of forests is necessary for forest management and it will be most rational if based on the notion of a forest ecosystem or biogeocoenosis. Krajina (29), who summed up the work of the symposium, stated that all the proposals to date for classifying forests could be

placed in three categories: 1) ecotopic, in which the main emphasis is laid on factors pertaining to the habitat (ecotope), these being subdivided into macroclimatic (climatic) and soil (edaphotopic); 2) biocoenotic, based on the characteristics of the biocoenoses, which are subdivided into phytosociologic (phytocoenotic) and zoosociologic (zoocoenotic); and 3) ecosystematic or biogeocoenotic (holocoenotic), a combination of the main elements of 1) and 2). After considering these categories as suggested by various authors, including Russian and Soviet scientists, Krajina calls attention to the "interesting and holocoenotically more comprehensive conception of biogeocoenoses recently put forward in the Soviet Union." This concept, he adds, "seems to be ideal for classifying the ecosystems anywhere in the biosphere." (29, p. 4). He says that acceptance of this point of view is encountering difficulties even though both the concept and term "forest biogeocoenosis" have been used by some Western European scientists. Yet Krajina himself still defines a plant association as an essential unit of a biogeocoenosis (forest type). He also notes the importance of this comprehensive approach to finding solutions for the practical problems confronting forestry.

Even those authors representing the ecotopic or phytocoenotic schools of thought (Arnborg, 23) do not challenge the importance of ecosystematic or biogeocoenotic classifications. They merely emphasize that the vegetation (phytocoenosis) is a good indicator of the ecosystematic (biogeocoenotic) properties of a forest. Moreover, most of the authors concede that the terms "ecosystem" (holocoenosis) and "biogeocoenosis" are quite similar.

Here are some other views presented at the symposium.

Scamoni (37) thinks that a common platform on which to unify the different schools of forest type classification can be found in the idea of biochore, as understood by Palman and Etter, or in biogeocoenosis. He regards biogeocoenosis and biochore as synonyms.

Daubenmire (24) observes that forest classifications are likely to differ depending on the purpose for which they are made. He raises the question of whether there can be a classification more fundamental than the others which will best reflect the harmony existing between the composition and dynamics of vegetation, soil, and climate and thus be useful in exploiting forests. His reply is that agreement on the concept of an ecosystem makes such a classification possible, although there may be many qualifications.

Rowe (36) is more skeptical. He writes that while it may be logical for a forester to regard a forest as an ecosystem — the underlying ideas are both philosophical and practical in import — nevertheless the phytocoenosis as a means of evaluating the ecosystem is useful in obtaining the most significant information that needs to be known about it. The general basis of a forest typology must be an ecosystem combining both the biotic aspects and those of the surrounding forest environment. He concludes, however, by remarking that there are various ways of subdividing a forest into an ecosystem, depending

mainly on the purpose, which determines the methods and scale of the investigation as well as the appropriate classification criteria. Therefore, coordination of different typological systems is in practice neither possible nor desirable.

Still another term used at the Ninth International Botanical Congress was "site," suggested by the Canadian scientist Hills (27). He has developed it in detail in several papers, in one of which (20) he wrote: "Climate, relief, soil, plants, and animals form the major parts of the (surrounding) whole called a 'site'." "Site" means literally a "location," but here he uses the word in the sense of the set of things in which the forester is interested. He says further on that "a site is a combination of those external factors with which the forester must deal in growing trees and exploiting forest products." He also believes that in classifying forests it is not enough to consider each component of the "site." The classification must be based on the interrelation of all the components. This is the holistic (from the Greek word *holos* meaning whole) approach. The whole, which is more than the simple sum of the parts, is strived for. A forest ecosystem is divided into four subordinate systems: 1) ecoclimate; 2) soil, including adjacent geological formations; 3) vegetation; and 4) mesofauna. It is not clear why the author mentions only mesofauna, since both macrofauna and microfauna play a role in the life of a forest, like any other vegetation. An examination of other works of Hills reveals that he has worked out most thoroughly the idea of the second subordinate system (component) — soil — for the description of which he presents a very detailed program. Yet in his paper read at the Botanical Congress he considers "site" as a special case of ecosystem, noting that throughout a "site" the system of interactions of the previously-mentioned living and dead components of nature remains uniform.

Thus, the Ninth International Botanical Congress almost unanimously recognized the idea of ecosystem or biogeocoenosis. We still face the problem of whether the two words can be regarded as synonymous and, if so, which is to be preferred. The older of the two is ecosystem, but both are undoubtedly antedated by "epigene" proposed by Abolin (1). Expressiveness is a factor that should be taken into consideration in resolving the problem. Tensley (22, p. 299) looked upon his ecosystem as embracing an association of the complex of living organisms ("biome" in Clements' sense) with the complex of physical environmental factors, i.e., the factors of the habitat in the broad sense of the term as one of the diverse physical systems of the universe (down to and including the atom). His very concept of a system is vague and used in a great variety of meanings, even excluding at times the existence of mutual influence between the objects composing a system, e.g., system of taxons. Since the existence of mutual influences or interaction of the components is the most characteristic feature of the concept in question, we believe that "biogeocoenosis" (from the Greek words *koinos* "common" and the prefixes *bio* "life" and *geo* "earth," which emphasize the participation in this general unity of living things and inert elements of the earth's surface) is the more accurate and descriptive term.

Site" is even less accurate than "ecosystem." "Biogeocoenosis" is undoubtedly the word that is closest to reflecting the essence of the concept.

In addition, biogeocoenosis has quite concrete content. Just as a phytocoenosis in the view of Soviet phytocoenologists is not a general expression for all the categories of plant taxons, so a biogeocoenosis is not a general expression for all the taxonomic subdivisions of a biotic community. A phytocoenosis is any area of vegetation characterized throughout by a well-defined, highly complex system of plant interrelations; similarly, a biogeocoenosis is an area characterized throughout by a well-defined, even more complex system of interactions between its living and dead natural components that remains uniform, i.e., a uniform system of obtaining and transforming matter and energy and exchanging them with neighboring biogeocoenoses and other natural bodies.

The processes of transforming matter and energy in biogeocoenoses and exchanging them with other natural bodies depend on: 1) the properties of their primary constituents (plants, animals, microorganisms, atmosphere and lithosphere, rock characteristics, hydrological conditions) and their distribution within the biogeocoenoses; 2) the conditions under which these constituents become active, e.g., the relief and climate of their existence; 3) the nature of the environment of the biogeocoenoses; and 4) the nature of a secondary constituent of bioinert (Verbitskiy) character, which is the sum total of the interactions.

This idea was well expressed 35 years ago by the leading Soviet soil scientist B. B. Polynov. Using the phrase "elementary landscape" in a sense close to that of "biogeocoenosis," Polynov (1, p. 82) wrote: "The soil is a total region of the landscape; it differs significantly from animals, plants, and rocks in not having, strictly speaking, its own original material. It does not come from without to adapt itself in any way or another to the landscape. From the beginning of its formation it is a product of the landscape and therefore reflects the properties of the landscape to a greater extent than any other element." In a sense soil is the resultant of the processes taking place in a biogeocoeno-

sis since the goal of biogeocoenology is to understand the principles governing the processes of transforming matter and energy in biogeocoenoses and the relations between biogeocoenoses. For the purpose of controlling these processes in the interests of man, it is easy to see why a study of soil with special reference to the biogeochemical side of the process of soil formation is the interesting papers of V. R. Volobuyev) is important.

Therefore, a biogeocoenosis may be defined as any portion of the earth's surface containing a well-defined system of interacting living organisms (vegetation, animals, microorganisms) and the lithosphere, atmosphere, hydrosphere) and its components, i.e., a system of obtaining and transforming matter and energy and exchanging them with neighboring biogeocoenoses and other natural bodies that remains uniform.

The continuous interaction of all the components among themselves and with surrounding natural objects means that each biogeocoenosis is a dynamic phenomenon constantly moving, changing, and developing. Climax (mature, stabilized) biogeocoenoses may be regarded as having reached a comparatively stable phase of development. Such communities may become established anywhere on the earth, covered by water or not, if inhabited by living organisms.

As noted previously, the term biogeocoenosis was used as a synonym for ecosystem by a number of scientists at the Ninth International Botanical Congress. Ecosystem is rarely used in the Soviet Union, whereas biogeocoenosis is becoming increasingly popular. It is found in the writings of soil scientists (A. A. Rode, S. V. Zonn, V. R. Volobuyev, etc.), geobotanists (Ye. M. Lavrenko, A. P. Shennikov, etc.), and in apparently only remotely related studies (e.g., by I. I. Shmal'gauzen on species formation and cybernetics, N. V. Timofeyev-Resovskiy on species formation and radioactive substances in soil, water, living organisms, etc.).

Some geographers have taken an unusual position in this respect. It is a well known fact that Berg (2) suggested "facies" for a concept resembling a biogeocoenosis. The term was subsequently adopted by several other geographers, notably Solnetsev (12, 13) and Isachenko (8). We have already commented critically on the term (18), but since it has very recently come up again in geobotanical literature, we feel another discussion of it to be essential.

"Facies" is of course widely employed in geology. Some valuable studies of general character have appeared of late on facies (9, 10). However, the concept is not always understood the same way even in geological literature, as D. V. Nalivkin and V. P. Markevich pointed out. After analyzing various definitions of the concept, Markevich says: "Taking cognizance of the basic idea of facies as well as the content added by most investigators, we suggest the following definition. A facies or geological facies is a deposit of soil or rock characterized by a compatible complex of paleontological, petrographic, and physicochemical properties caused by the tectonic, physicochemical, biotic, and geographic conditions under which the deposit was formed." Nalivkin (9, p. 7) stresses the close association between the formation of a geological facies and a specific landscape, a particular biogeocoenosis, which is more or less accepted by other geologists as well. However, even though the formation of a geological facies in which the main role is played by sedimentation processes is associated with a particular landscape,¹ and sometimes with a par-

¹ I am not going into the difference between landscape and biogeocoenosis here because I have already devoted a special article to the problem (18). Although I consider a biogeocoenosis a structural part of a landscape (just as every single plant is in a certain sense a structural part of a phytocoenosis), I believe that the two concepts are theoretically different. I now recognize that biogeocoenosis and phytocoenosis aren't purely geographical concepts, but that like other phenomena on the earth's surface they can be studied from the standpoint of geographical distribution.

ticular biogeocoenosis, it does not follow that a geological facies is a biogeocoenosis or that the two terms are synonymous. The one must not be substituted for the other.

It is likewise impossible to agree with Sochav (14) who writes that facies is no longer used with reference to major categories of physiogeographic zoning.² Following Berg (2), it is desirable to apply it to very small typological landscape subdivisions, thus facilitating the task of making comparisons with paleogeographic facies, which "include a biocoenosis, biotope, and sedimentary rock" (9). "A biogeocoenosis is a physiogeographic facies, but understood as an energy system. With the biogeocoenotic approach, according to Sukachev (15, 17), a facies is investigated from the standpoint of exchange of matter between living organisms and the abiotic environment, of the transformation of energy and its movement within the facies." Nalivkin's observation that a facies "includes a biocoenosis, biotope, and sedimentary rock" should be taken to mean, as we pointed out previously, that a facies is associated with a specific biocoenosis and biotope at the moment it is formed. This follows from the masterly work of Nalivkin (9) and the other geological studies already mentioned.

Furthermore, it is scarcely desirable to designate the same phenomenon in different ways depending on how it is being considered—from the geographic point of view or as an energy system. A phenomenon should naturally be given a single name, although it can and must be considered and studied from various aspects.

Sochav (14) reveals some lack of clarity in regard to facies and biogeocoenosis when he says: "Both the fundamental type of biocoenosis and the temporary groupings derived from it as a result of changes in plant and animal life directly or indirectly caused by man correspond to physiogeographic facies. Continuously produced plant associations and the corresponding biocoenoses in all cases where substantial changes in soil formation, course of hydrological processes and hydrological regime accompanied changes in the vegetation, are a component of specific anthropogenic facies." It is impossible to accept this view. If we agreed with Sochav and considered facies and biogeocoenosis synonymous, then the fundamental and temporary biogeocoenoses derived from them would have to be assigned, in accordance with what has just been quoted, to one type of biogeocoenosis and the continuously produced associations to another

type. This is impossible, for both associations would have to be assigned to another type of biogeocoenosis if only one of the components were substantially changed (e.g., the make-up of a stand of trees).

We said that since the same term sometimes has several meanings in different branches of knowledge, facies might be understood variously in landscape science, geology, phytocoenology, and soil science. This is generally undesirable. It is permissible in an extreme case, but only when the branches of knowledge are not related. Here, though, the foregoing disciplines are closely related and in part coordinated so that use of the same term in different meanings is not a good idea, for it may spread confusion; indeed, it has more or less already done so.

We stated previously that in nature all phenomena and objects are mutually related, but the character of the relationships varies in the different groups of phenomena and objects. It is obvious that the interaction of organic matter with the environment in which it occurs is specific and different in character from the interaction of the plant and animal worlds, from the interaction of the soil, atmosphere, hydrological conditions and rocks, and from the interaction of the elements of the same component of a biogeocoenosis, e.g., among the plants of a phytocoenosis or animals of a zoocoenosis.

One of the specific features of these unities calls for special attention. Each organism and each specimen is in dialectical unity with the environment. However, if we consider this unity in terms of the evolution of the organisms, we note the remarkable fact that its characteristic change in a definite direction as we proceed up the evolutionary ladder from the simplest organisms. The dependence on the environment of the unicellular organisms in particular, which have no membrane, is direct and most pronounced. The influence of the organisms on the environment is comparatively slight. Moving up the evolutionary ladder, however, we see that they increasingly acquire powers of organization aimed at weakening the direct effect of the environment on them while striving to change it as much as they can. This is achieved by the development of adaptive mechanisms that protect them from unfavorable influences, e.g., cell membranes in protozoans, and by the organism changing environmental factors in a more favorable direction. Thus, evolution does not destroy their interaction with the environment on which they depend or their dialectical unity with it. At the same time, however, the nature of this unity changes, acquiring new characteristics as a result of the greater independence of the organisms and changes in the influence of external environmental factors through weakening the harmful ones and strengthening the useful ones. The steady growth of relative autonomy is not due to any purposive mystical tendency inherent in living things. It is rather the outcome of the struggle among them for existence and against unfavorable environmental factors and the resultant natural selection.

This is essentially the process that takes place in the development of a phytocoenosis as a whole. Individual, isolated plants are exposed to a variety of unfavorable environmental influ-

² The term facies was first proposed by S. I. Korzhinskiy (1888) in a very broad sense (e.g., facies of coniferous forests). However, more recently it has also come to be used in West European literature for minor variants of a plant association. It has been, and still is, used in a great variety of meanings. An attempt was made not long ago to introduce it into soil science. However, in soil science (4, 5) it has a very broad sense, e.g., the central chernozem facies embraces the chernozem belt in Western Siberia and the European part of the USSR with a variety of climatic conditions, vegetation, and animal life.

es, but plants near one another are less affected by them. The natural, so-called synthetic succession of phytocoenoses moves toward the perfecting of a phytocoenosis capable of maximally changing the environment by eliminating properties deleterious to the life of plants and by creating useful ones. This relative autonomization of phytocoenoses proceeds not by weakening their connection or unity in the environment, but by subduing and altering it. The relative degree of organization of a phytocoenosis, like that of an individual organism, may and should be measured by its ability to change the external environment, i.e., to create a biosphere as different as possible from the original environment and lacking the factors unfavorable for the plants. Such perfecting of a phytocoenosis is again the outcome of the struggle for existence among the plants and resultant natural selection. The process proceeds at the same time toward the development of a phytocoenosis that makes fuller use of the resources of the environment. However, when these resources diminish or are so redistributed in the soil that they cannot nourish the association of organisms, the phytocoenosis becomes degraded or simplified.

How is this process of progressive, relative autonomization of organisms and phytocoenoses related with the dynamics of the biogeocoenosis as a whole and with the dynamics of its other components? It is self-evident that changes in the phytocoenosis with time affect the dynamics of the other components of the biogeocoenosis as well as the biogeocoenosis as a whole. However, changes take place in the biogeocoenosis due to the action of the phytocoenosis and zoocoenosis and to changes in its other components. The plants may evolve by steadily modifying the environment and gaining greater freedom from its direct influence, but neither the other components of the biogeocoenosis (e.g., local portions of the atmosphere, lithosphere, and hydrosphere) nor the biogeocoenosis as a whole can follow this line of evolution. Their development follows other laws determined by the particular nature of this or that component and by the character of its interrelations with the other components. The problem of the development of a zoocoenosis and biogeocoenosis calls for more study. The biogeocoenosis as a whole develops through the interaction of all its variable components and in accordance with special laws. The very process of interaction among the components constantly disrupts the established relationships, thereby affecting the evolution of the biogeocoenosis as a whole. Therefore, investigation of the specific laws governing the evolution of each component does not preclude the need of studying the laws of evolution of the biogeocoenosis as a whole. The latter is more than the simple sum of its components and laws of development. The biogeocoenosis as a whole has its own distinctive qualities.³

I began to discuss the relationship between a biogeocoenosis and its components in a series of articles going back to 1941. It is therefore difficult to understand why I am said "to contrast (quite wrongly) biogeocoenosis with habitat in combination with which it is supposed to form a biogeocoenosis. If this were the case, it would appear that a biocoenosis could exist

That is why an investigation of the evolution of a biogeocoenosis as a whole cannot substitute for an investigation of the evolution of each of its components. Similarly, one should not substitute the concept of biocoenosis (or biocomplex) for the concept of biogeocoenosis, as some have suggested, because the former is to be viewed simply as part of the latter.

It is clear from the foregoing that biogeocoenology does not deal with the same things as other scientific disciplines that are engaged in studying the individual components of biogeocoenoses. However, soil science, as noted previously, condenses and clearly reflects the biogeocoenotic processes and thus is especially close to and important to biogeocoenology. But this does not mean that soil changes are always the leading factor in the evolution of a biogeocoenosis as a whole. If sufficiently dense, the vegetation may constitute this factor. The influence of its other components may do so in other cases. Since all the interactions of the components of a biogeocoenosis are ultimately reflected in the exchange of matter and energy between them as well as between them and surrounding natural bodies, the biogeocoenosis as a whole should be regarded as a natural laboratory in which are consummated the processes of storage and transformation of solar energy consisting of many diverse chemical, physical, and physiological processes that likewise interact.

Consequently, the study of biogeocoenoses requires a comprehensive method utilizing the achievements of physics, chemistry, and mathematics as well as those of meteorology, soil science, hydrology, and biology. It must be remembered that the cosmic biogeochemical role of living matter is performed by biogeocoenoses, by biogeocoenotic processes. Hence the vast general theoretical and practical significance of biogeocoenology.

Received March 16, 1960

BIBLIOGRAPHY

1. ABOLIN, R.I. 1914. Tentative epigenological classification of bogs. Bolotovedeniye, No. 3.
2. BERG, L.S. 1945. Facies, geographical aspects, and geographical zones. Izv. Vses. geogr. ob-va Vol. 77, No. 3.

independently of a habitat" (6, p. 239).

Equally surprising is this quotation from Ioganzen: "Sukachev is now considering plants along with animals ('bio'), but he deals only with the earth's surface ('geo'), ignoring air, soil, and water as unique living environments" (p. 238). He adds: "Postulating the division of a biogeocoenosis into several components, the biogeocoenotic theory distracts the investigator from studying those laws which exist in nature and are particularly reflected in the development of diverse biocoenoses" (p. 239). My ideas on the relationship between a biogeocoenosis and its components have nothing in common with the incorrect views ascribed to me by Ioganzen and with his general conclusions concerning the theory of biogeocoenosis in general (cf. 7, p. 83).

3. VILLEE, K. 1959. Biology. Translation from the third edition.
4. GORSHENIN, K. P. 1960. A contribution to soil classification. *Pochvovedeniye*, No. 1.
5. IVANOVA, YE. N. and N. N. ROZOV. 1958 and 1959. Tentative classification of steppe-zone soils. *Pochvovedeniye*, 1958, No. 12; 1959, No. 1.
6. IOGANZEN, B. G. 1959. Principles of ecology. Tomsk.
7. IOGANZEN, B. G. 1959. Controversial questions in modern ecology. *Soobshcheniye 2-ye. Izv. Sibirskogo otd. Akad. Nauk SSSR*, No. 9.
8. ISACHENKO, A. G. 1953. Main problems of physical geography. Leningrad.
9. NALIVKIN, D. V. 1956. Theory of facies. I and II.
10. MARKEVICH, V. P. 1957. Concept of "facies."
11. POLYNOV, B. B. 1925. Landscape and soil. *Priroda*, No. 1-2.
12. SOLNTSEV, N. A. 1948. Main stages in the development of landscape science in the USSR. *Vopr. geografii Sb.* 9.
13. SOLNTSEV, N. A. 1949. Morphology of the natural geographical landscape. *Vopr. geografii*.
14. SOCHAVA, V. B. 1959. Plant classification and typology of physico-geographical facies. Materials on classification of Ural vegetation. *Izd. Ural'sk. filiala Akad. Nauk SSSR*.
15. SUKACHEV, V. N. 1945. Biogeocoenology and phytocoenology. *Doklady Akad. Nauk SSSR*, 47, No. 6, Nov. seriya.
16. SUKACHEV, V. N. 1948. Phytocoenology, biogeocoenology, and geography. *Tr. 2-go Vses. geogr. s'yezda*, I.
17. SUKACHEV, V. N. 1955. Main problems in forest biogeocoenology. *Botan. zh.* 40, No. 3.
18. SUKACHEV, V. N. 1949. Relationship between the concepts of geographical landscape and biogeocoenosis. *Vopr. geografii. Sb.* 16.
19. TIMOFEYEV-RESOVSKIY, N. V. 1959. Principles in classifying biochorological units. Materials on classification of Ural vegetation. *Izd. Ural'sk filiala Akad. Nauk SSSR*.
20. HILLS, A. G. 1952. The classification and evaluation of site for forestry. Ontario.
21. MAJOR, J. 1958. Plant ecology as a branch of botany. *Ecology*. Vol. 39, No. 2.
22. TENSLEY, A. G. 1935. The use and abuse of vegetation concepts and terms. *Ecology*. 1
23. ARNBORG, Dr. T. (Sweden). Can we find a common platform for the different schools of forest type classification? Paper read at the symposium on the forest ecosystem. Ninth International Botanical Congress, 1959.
24. DAUBENMIRE, R., Prof. (USA). Some major problems in vegetation classification. *Ibid.*
25. ELLENBERG, H., Dr. Prof. (Switzerland). Can we find a common platform for the different schools of forest type classification? *Ibid.*
26. HILLS, A. G. (Canada). The Ontario approach to forest site classification. *Ibid.*
27. HILLS, A. G. (Canada). Comparison of forest ecosystems (vegetation and soil) in different climatic zones. *Ibid.*
28. KALELA, A., Dr. Prof. (Finland). A general review of the classification of forest vegetation, especially with reference to regional research problems. *Ibid.*
29. KRAJINA, V. J., Prof. (Canada). Can we find a common platform for the different schools of the forest type classification. *Ibid.*
30. KUECHLER, A. W., Dr. (USA). Comparison of forest ecosystems (vegetation and soil) in different climatic zones. *Ibid.*
31. KUJALA, V., Prof. (Finland). Can we find a common platform for the different schools of the forest type classification? *Ibid.*
32. LINTEAU, A., Dr. (Canada). Y a-t'il un terrain d'entente possible entre les différentes écoles au sujet de la classification des types forestiers? *Ibid.*
33. MEDWECKA-KORNAS, A., Dr. (Poland). Some problems of forest climaxes in Poland. *Ibid.*
34. OVINGTON, J. D., Dr. (England). The ecosystem concept as an aid to forest classification. *Ibid.*
35. PURI, G. S., Dr. (India). The concept of climax in forest Botany as applied in India. *Ibid.*
36. ROWE, J. S. (Canada). Can we find a common platform for the different schools of the forest type classification? *Ibid.*
37. SCAMONI, A., Prof. (German Democratic Republic). Can we find a common platform for the different schools of forest type classification? *Ibid.*
38. SUKACHEV, V. N., Dr. Prof. (USSR). The correlation between the concept "forest Ecosystem" and "forest Biogeocoenose" and their importance for the classification of forest. *Ibid.*
39. WEBB, L. J., Dr. (Australia). A new attempt to classify Australian Rain forest. *Ibid.*

A NEW GROUP OF SOILS UNDER DARK CONIFEROUS FORESTS IN EASTERN TIBET

L. V. ZONN and I. I. FEOFAROVA,¹ Forestry Laboratory, Academy of Sciences, USSR

In recent years Soviet soil scientists have made substantial contributions to our knowledge of the genesis of Soviet and foreign soils. They have confirmed the soundness of Dokuchayev's principles and at the same time revealed the urgency of developing them creatively in the light of the infinite variations among the factors responsible for soil formation. Dokuchayev's observation that "nature is not mathematics and at there is, so to speak, ... no dry mathematical monotony" (3, p. 320) is pertinent. It is a profound statement and a warning to soil scientists against an oversimplified interpretation of the principles governing the development and distribution of soils and the factors determining them.

The teaching on the factors affecting soil formation has been repeatedly reexamined of late, but it has not as yet been sufficiently clarified. Postulating both the equivalence and the leading biological factors (vegetation, in particular), the extreme views of the latter by Ponomareva (8), are frequently at variance with the natural processes of soil formation and the soil groups to which they give rise. This discrepancy is shown into relief by investigations of mountain forest soils in Eastern Tibet and Bulgaria, for they have shown that different soil groups can be formed under spruce forests similar in composition.

The Variety of Soil-Forming Processes Under Spruce Forests

There is a prevalent view in Soviet literature on soil science and silviculture that it is chiefly soils of the podzolic group that develop under spruce forests. This is attributed to the biological properties of spruce and character of their decomposition which is determined by the peculiar phytoclimatic conditions created in spruce forests.

We have pointed out on several occasions (4), that this popular idea of the podzolizing role of spruce is not supported by actual observations and that the influence of spruce forests on soil

formation cannot be understood apart from the climatic conditions under which they grow.

Our recent research on the soils of spruce forests in Southern Bulgaria (4, 5, 6) and in the mountainous part of Eastern Tibet has revealed once again the great variety of soil-forming processes present. It will be recalled that spruce stands in Southern Bulgaria are found at 1600-2200 m elevation in a sub-Mediterranean climate transformed by altitude, with as much as 1000 mm of precipitation, high summer temperatures, with a dry period extending from June to September, and no soil freezing in winter. It is noteworthy that Bulgarian spruce forests have the type of vegetation characteristic of spruce stands of the taiga zone; whortleberry-green moss spruce² is the most abundant type.

In Eastern Tibet spruce forests are found at altitudes of 3300-3700 m, fir forests at altitudes between 3600 and 3900 m above sea level. They are adapted to the subtropical zone where the climate is also drastically modified by the altitude and by the influence of the mountain ranges surrounding them. About 1000 mm of precipitation falls a year with monsoon distribution. Temperatures are high in summer and moderate in winter (7). The continental quality shows up in the daily variations in temperature. It is less pronounced, however, from year to year.

Spruce forests are made up chiefly of *Picea purpurea*, fir forests of *Abies faxoniana*, *A. recurvata*, and others.³ The commonest types of forests are moss-bamboo (*Sinarundinaria*) spruce and rhododendron-fir.

Soil samples of similar textures were obtained for purposes of comparison but soils developed on different soil-forming material (clay loams from shale weathering, gneisses, and morainic clay loams). However, the effect of the latter is less pronounced than that of the forest vegetation under different climatic conditions.

The data of Figure 1 show very clearly the

² The spruce is the same as in the USSR - *Picea excelsa*.

³ Despite the species differences, ash content of the needles and the litter do not differ significantly from ours.

In thin section analyses, description of the micro-biological structure and mineralogical composition of the soils were the work of I. I. Feofarova.

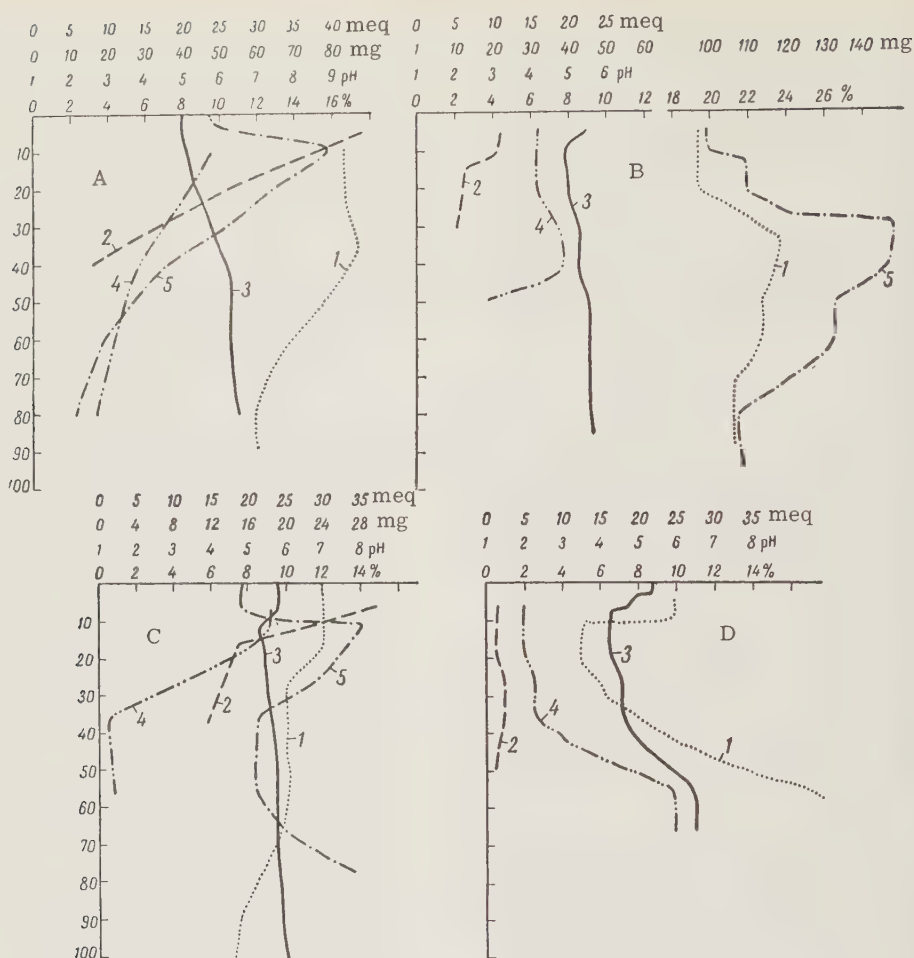


Fig. 1. - Distribution in soils:

1 - % particles < 0.001 m in diameter; 2 - humus, %; 3 - pH; 4 - total exchangeable cations, meq; 5 - mobile iron (according to Kursanov), meq per 100. A - high mountain-forest soil under Eastern Tibetan spruce forests; B - the same, under fir forests; C - mountain-forest dark soil under Bulgarian fir forests; D - strongly podzolic soil under spruce forests, Vologodskaya Oblast'.

almost total absence of movement of clay particles (< 0.001 mm in diameter) in the soils of Bulgarian and Eastern Tibetan spruce forests, which is quite marked in the soil of Vologodskaya Oblast' with the sharp quantitative decreased clay in horizon A₂ that is characteristic of podzol formation. To this should be added the micro-aggregation of the former and extreme dispersion of the latter.

There is rapid accumulation of humus substances in Bulgarian and Eastern Tibetan soils to a depth of 40 cm or more. In the Vologodskaya soil, on the other hand, the humus content is low with distinct mobility and accumulation in horizon B. Accordingly, the distribution of exchangeable cations in the first of these soils is altered, the amount being substantial in horizon A and gradually decreasing with depth, whereas in the second soil they are distinctly redistri-

buted—less in horizon A and more in horizon B. The actual acidity (pH) changes in various ways through the profile of these soils. In Bulgarian soils it increases very slightly with depth as well as under litter. Tibetan soils exhibit a clear, gradual decrease with depth, whereas the Vologodskaya soil exhibits a sharp increase in horizon A₂ and decrease in horizon B. Increased content of mobile iron (using Kursanov's method) in horizon A and decrease thereof with depth is very characteristic of Tibetan soils. It behaves the same way in horizon A of Bulgarian soils, decreases in horizon B, and accumulates in horizon C. Thus, the distribution of mobile iron in the former indicates the absence of leaching while in the latter it indicates great mobility and possible leaching into the lower part of the profile.

These major differences between podzolic s

Depth, cm	Ignition loss	SiO ₂	R ₂ O ₃	Fe ₂ O ₃	Al ₂ O ₃	CaO	MgO	P ₂ O ₅	SO ₂	MnO
Soil. Under a spruce forest, altitude 3300 m above sea level (profile 11)										
0-2	40,38	69,72	22,05	4,41	17,17	1,95	0,87	0,47	0,40	0,018
4-9	27,14	73,52	23,47	4,68	18,56	1,03	0,44	0,22	0,25	None
12-20	16,83	72,74	24,22	5,16	18,94	0,72	0,49	0,11	0,04	"
30-40	10,45	69,40	27,48	7,69	19,77	0,71	0,90	0,02	0,05	Trace
70-80	6,49	69,60	25,42	6,05	19,36	0,61	1,32	0,01	0,10	0,04
Soil. Under a fir forest, altitude 3710 m above sea level (profile 11)										
0-5	61,04	58,37	24,60	3,78	17,46	3,70	1,56	0,65	0,76	0,13
5-15	15,55	71,66	20,92	4,27	16,48	0,73	0,80	0,16	0,31	Trace
15-22	11,13	73,43	24,66	4,88	19,67	0,60	0,90	0,11	0,16	"
30-40	14,14	67,32	29,56	8,20	21,19	0,76	1,06	0,16	0,10	None
80-85	6,49	65,80	27,91	5,78	22,04	0,90	1,50	0,09	0,14	0,04
Clay fraction (<0,001 mm)										
		SiO ₂	R ₂ O ₃	Fe ₂ O ₃	Al ₂ O ₃	CaO	MgO	P ₂ O ₅	SO ₂	MnO
		50,22	39,47	8,94	29,29	0,77	4,67	1,24	0,60	None
		45,77	47,43	9,63	36,53	0,56	4,04	0,97	0,20	0,09
		43,85	48,67	15,20	32,76	0,62	4,17	0,71	0,24	0,04
		41,85	49,75	14,38	34,64	0,64	5,27	0,68	0,16	0,11
		49,65	37,48	10,32	26,73	0,82	1,39	0,46	0,30	None
		49,32	37,92	9,33	28,28	0,69	1,69	0,31	0,21	Trace
		45,88	50,56	19,04	30,86	0,62	1,49	0,66	0,40	"

Note: Comma represents decimal point.

and the soils under Bulgarian and Tibetan spruce forests seemed to justify our classifying the former (according to Antipov-Karatayev [1]) with the special group of dark mountain-forest soils and to compare the latter—at the initial stage of investigation—with the brown mountain forest soils, taking into account their provincial differences which are characteristic of high-altitude conditions. However, further study of these soils in 1959 in the more southern regions, additional data on their properties, and a comparison with the soils under fir forests led us to doubt the correctness of classifying them in the brown mountain-forest soil group. In the soils of fir forests, unlike those of spruce forests, removal of the clay fraction, mobile iron (according to Kirsanov), and exchangeable cations in horizon B is quite pronounced, which correlates with changes in their active acidity. They accumulate much less humus and the amount drops sharply with depth.

These data show fairly convincingly that: 1) soils are formed with different properties under spruce forests; 2) their properties clearly correlate with each other, thus testifying to a regular rather than chance pattern in the changes that take place; 3) their differences from typical podzolic soils are so substantial as to reveal the existence of a completely different type of soil formation.

Justification for Identifying Spruce and Fir Forest Soils as a Special Group

The morphology of soils under the spruce forests of Eastern Tibet, as we pointed out earlier (7), reveals no distinct signs of podzolization. We noted an insignificant whitish color in horizon A₂ of soils under fir forests. However, all the soils are marked by excellent structural and micro-aggregation. Moreover, the fir forest soils at altitudes of 3700-3900 m have a fairly distinct illuvial horizon changing into a humus-illuvial horizon, frequently with indications of buried horizon, which clearly distinguishes them from soils of the podzolic group. The absence of a pronounced gleyed horizon (B) in spruce stand soils throws doubt on the appropriateness of classifying them with the brown forest soil group.

Total chemical analyses (Table 1) show that soils under spruce stands do not show the clear increase in SiO₂ and decrease in R₂O₃ in the top horizons characteristic of podzol formation. Some increase in silica at depths of 4-20 cm is chiefly due to its entry from the needles because the SiO₂ content of the litter is almost 68%. In addition, there is evident biological accumulation of calcium to a depth of 70 cm in these soils. Only magnesium is subjected to leaching from the upper layer. The R₂O₃ present in abundance throughout the profile and increasing slightly with depth at the expense of Fe₂O₃ is particularly characteristic. The Al₂O₃ is evenly distributed throughout the profile, excluding the litter. This shows the stability of the clay minerals of the kaolinite group and their very weak migration.

In the clay fraction R₂O₃ predominates over SiO₂ in the entire layer, except the top 9 cm, where there is more of the latter for the reason already cited. The increase in Fe₂O₃ content

beginning with the 30 cm depth proves that it is more mobile than Al_2O_3 ; some decrease in the latter is noted only in horizon A (4-9 cm). Distribution of the remaining oxides confirms their accumulation in the clay fraction of the upper horizons too, which indicates both the stability of the clay minerals and their synthesis. We find, in general, stability of the mineral composition of spruce stand soils with considerable total accumulation of R_2O_3 and movement of Fe_2O_3 into the lower horizons.

The substantial accumulation of R_2O_3 makes these soils resemble subtropical soils and testifies to their total lack of the properties characteristic of podzol formation. These properties are not observed in the dark soils of Bulgaria, but they differ from those described in possessing lower Fe_2O_3 content with depth, which suggests accumulation rather than leaching as well as higher Al_2O_3 and CaO content, possibly due to the difference in soil-forming parent material.

Soils under fir forests have a more appreciable quantity of SiO_2 at a depth of 5-22 cm (Table 1), decrease in Al_2O_3 and, especially, Fe_2O_3 , with sharp increase in horizon B (30-40 cm). The composition of the clay fraction reveals this quite clearly. However, the distribution of Al_2O_3 does not indicate that it moves through the profile of these soils. Besides the leaching of Fe_2O_3 , there is comparatively more rapid biogenic accumulation of CaO, MgO, P_2O_5 , SO_3 , and even MnO than in spruce stand soils. In general, the main differences between these soils lies in the uneven mobility of iron. Owing to the extensive leaching of iron from the top horizons of fir stand soils, their morphology creates the impression that they are in the initial stages of podzol formation. However, the other properties, as will be shown below, do not confirm the development of this process.

Observations have shown that the top horizons

of these soils have signs of excessive moisture in the spring and first half of the summer, suggesting the possibility that part of the iron has shifted from ferric to ferrous, which accounts for its increased mobility and more rapid leaching. The latter is indicated by the distribution of mobile iron through the profile (Fig. 1) and the results of determining it in an oxalate extract (Table 2). A sharp decrease is found in Fe in horizon A and increase in horizon B (30-40 cm), with simultaneous increase of mobile SiO_2 in the upper 10 cm.

No such leaching of Fe and accumulation of SiO_2 are observed in spruce stand soils. The content of mobile Al_2O_3 compounds increases in both soils. They differ markedly from the dark mountain-forest soils in content of mobile Fe and Al. In these soils the Al_2O_3 content is low while that of Fe_2O_3 is higher in the top horizons and it is not redistributed. Thus, the mobility of iron is one of the characteristics of the soils of the Tibetan dark-coniferous forests.

The differences in mineral composition of the soils noted previously have also been confirmed by the results of thermal and electron microscopic investigations⁵ of the clay fraction conducted in our laboratory by L.O. Karpachevskiy. Minerals of the kaolinite group — kaolinite and halloysite with a substantial admixture of goethite and gibbsite — predominate in the clay fraction (Fig. 2). Kaolinite and halloysite are uniformly distributed through the profile; little movement has been noted. Only the goethite constant increases with depth.

Minerals of the montmorillonite and kaolinite groups are synthesized in the dark-mountain-forest soils of Bulgaria (9). Beidellite and amorphous substances predominate in podzolic soils with goethite and hydrargillite sometimes and kaolinite rarely present (2).

⁴ The amount of P_2O_5 increases appreciably in horizon B (30-40 cm) as well, which may be from the fact that it is leached along with Fe_2O_3 .

⁵ Conducted in the Laboratory of Soil Mineralogy, V.V. Dokuchayev Soil Institute, Academy of Sciences, USSR and interpreted by N.I. Gorbunov.

Table 2

Content of mobile SiO_2 and R_2O_3 , using Tamm's method, in mountain-forest soils as % of absolutely dry weight

Soil and region	Depth, cm	SiO_2	Fe_2O_3	Al_2O_3	Sum
High mountain-forest under spruce, Tibet	4-9	0,11	0,66	1,16	1,93
	12-20	0,21	1,12	0,56	1,89
	30-40	0,35	1,90	1,15	3,40
The same, under rhododendron fir, Tibet	5-10	0,34	0,15	1,07	1,56
	15-22	0,16	0,57	1,69	2,42
	30-40	0,19	1,53	1,34	3,06
Dark colored, mountain-forest soil under spruce stand with whortleberry-green moss, Bulgaria	5-15	0,25	0,88	0,42	1,55
	20-30	0,35	0,85	0,59	1,79
	46-56	0,21	0,37	0,49	1,07

Note: Comma represents decimal point.

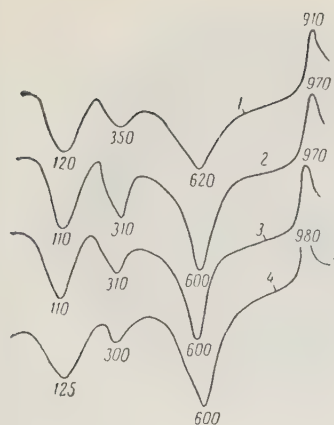


Fig. 2.- Thermal curves of clay fraction.

(<0.001 mm in diameter), isolated from high mountain-forest soil under an Eastern Tibetan spruce forest.

1 - AB, 8 - 30 cm; 2 - B₁, 30 - 68; 3 - B₂, 68 - 91; 4 - BC, 91 - 120 cm.

Thus, even in composition of clay minerals Tibetan soils differ significantly from dark and solonchaks, displaying marked resemblance with subtropical yellow earths and red earths.

We have already called attention to the high microaggregation of the soils. This is also confirmed by analyses of their micromorphological structure (Fig. 3). Some additional differences are found. For example, there are many phytolitharia at a depth of 5-18 cm in spruce forest soils with the typical forms of coniferous species (Fig. 3a). Clay-silt particles are evenly distributed and are represented by magnetite, partially oxidized, ferrihydrite, kaolinite, and other minerals. There are a few rock fragments in the form of quartz grains about 0.05 mm in diameter, acicular minerals 0.002-0.003 mm in diameter—hydrargillite and other fine particles, apparently from the kaolinite-halloysite group.

The clay part does not react to polarized light, which is determined by compounds of iron with colloidal iron hydrates, but in this case by the predominance of clays of the kaolin-halloysite group and by the absence of the morillonite clay group. They greatly differ in iron hydrates and rock fragments, the ferrihydrite being wholly converted into iron hydrates. The microstructure is aggregated, consisting in the mass of grains about 0.02 mm in diameter, adhering together in irregularly formed ribbed microaggregates. The pores between the grains and microaggregates are narrow. Isolation of these grains leads to coagulation of the clay substance by iron compounds, a characteristic of red earths.

The mineralogical composition of the sand-fine particles at a depth of 18-47 cm (Fig. 3b) is similar to that described previously but fibrous minerals are somewhat more abundant, quartz

and phytolitharia less so. The clay part does not react to polarized light. It is evident from the figure that the pores are very fine and the structure of the microaggregates more compact. Here and there microaggregates are formed by the activity of burrowing organisms. The soil is full of cracks.

The micromorphological structure of the fir forest soils resembles the preceding but with some differences (Fig. 3c, d).

The photograph shows good microstructure at a depth of 5-8 cm (Fig. 3c). Larger microaggregates (about 1.0 mm in diameter) have not yet broken up into smaller pieces. Some of them are well rounded and isolated from one another (Fig. 3d), with large pores in between. Several microaggregates have still not been formed, i.e., they are not completely separated, the pores between them are fine, showing different phases of microaggregation. Others are well formed microaggregates surrounded with very fine bands of polarized clay (optically oriented). Such microstructure is called "curd." Microaggregates are usually clayey with an intervening mass of coarser particles. Sand particles are also found in the microaggregates, but relatively large clay accumulation in the curds is normal. This is due to the fact that when the clay substance is drawn into aggregate-curd, the sand particles are freed from clay.

The reasons for microaggregation of the soil in the form of curds are not clear. In these soils humus substances, but not in the form of humic compounds, evidently promote microaggregation. This microstructure is not typical of podzolized horizons.

The clay part is represented by beidellite and kaolinized-hydromicaceous minerals. In reflected light the soils have a faint reddish coloration. Some rock fragments have been stained bright red by iron oxide. The phytolitharia are corroded. Fragments are represented by quartz-sericite-chloritic rocks, rarely with feldspars. Pore space between microaggregates is uncommon and largely due to roots.

At a depth of 8-19 cm (Fig. 3d), differences from the preceding samples are insignificant. The microstructure is well expressed. There are many fine microaggregates—grains looking intensely red in reflected light—which may indicate the coagulation of soils by a clay substance. At this depth the soil abounds in iron hydrates, but at a depth of 5-8 cm the iron is evidently bound with organic matter. The extensive and unusual curdy microaggregates of the soil are caused by the interaction of the kaolin-halloysite clay substance with iron-humus compounds, which determines the nature of their aggregation that is not characteristic of podzolic, brown, and dark soils. They are closest in this respect to subtropical soils. The differences between the soils of spruce and fir forests generally are a matter of more rapid weathering of rocks under the former, less rapid weathering under the latter. In the latter this is suggested by the presence of beidellite and hydromicaceous minerals with a lesser degree of kaolinization. At the same time the microaggregate structure of these soils is more distinct than under spruce forests.

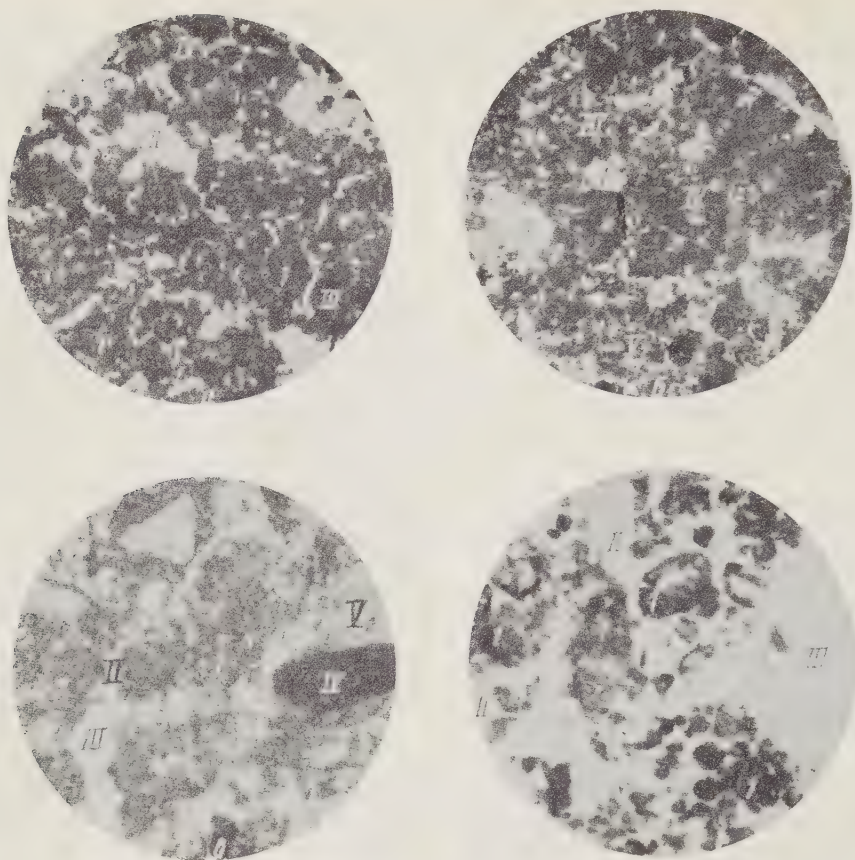


Fig. 3. - A - Microaggregate-grain structure in soil under a spruce forest, at a depth of 15-18 cm. Eastern Tibet. I - microaggregates divided by cracks into finer pieces; II - pores; III - pores - cracks; IV - rounded plant cell. Magnification 100X. Nicol II. B - Grain-aggregate structure with more compact consistence, in the same soil at a depth of 18-47 cm. I - quartz grain; II - large pores between microaggregates; III - fine pores between grains; IV - large microaggregates; V - large grains. Magnification 100X. Nicol II. C - Microaggregate-structure of soil under a fir forest at a depth of 5-8 cm. Eastern Tibet. I - microaggregates; II - pores in between; III - quartz; IV - iron rock fragment; V - fragment of quartz-sercitic rock. Magnification 100X. Nicol II. D - curdy microstructure in the same soil at a depth of 8-19 cm. I - microaggregates and grains; II - pores; III - quartz grain. Magnification 100X. Nicol II.

All these properties indicate that the faint whitish color of these soils is not due to podzolization. It is important to note too that it is not the humins, but some other compounds that are responsible for the microaggregation.

We assume that one of the main reasons for the difference between these and podzolic, brown, and dark forest soils lies in the peculiarities of formation of humus substances and their interaction with the clay part of the soils. Confirmation comes from data on the group composition of their humus substances as compared with data on dark, brown, and podzolic soils (Table 3).

It is only in the litter of soils under spruce forests that more fulvic acids are formed. Humic acids predominate in horizon A, which

determines the high ratio of C humic acids to fulvic acids not noted in other soils. The accumulation of humic acids agrees with all the other characteristics; they are bound chiefly with Fe and, probably, with Al. The fulvic acids predominate over the humic acids, which are also bound with Fe compounds, only in horizon B.

Soils similar in humus composition are close to dark mountain-forest soils, but differ from them in possessing a smaller amount of waxy-resinous compounds bound with Ca and a higher content of unhydrolyzable carbon residue. This difference is perhaps indicative of the smaller degree of condensation of humus compounds as well as of their firmer bond with the mineral part in the form of Fe and Al humates. They differ from brown forest, not to mention pod-

NEW EASTERN TIBETAN SOILS

Table 3

Group composition of humus substances in mountain-forest soils under spruce and fir forests as a percentage of carbon taken as 100

Soil and type of forest	Depth, cm	Total C	Wax-resins	Soluble in 1.0 n in Na ₂ SO ₄	Humic acids	Fulvic acids	Nonhydrolyzable residue	C of humic acids	C of fulvic acids
High mountain-forest under a bamboo spruce, Tibet	0-2	23,07	4,8	0,8	18,7	25,4	46,8	0,74	
	4-9	10,21	4,1	1,3	31,5	23,1	34,0	1,36	
	15-20	5,89	3,7	1,2	41,0	15,4	35,5	2,64	
	30-40	1,86	3,2	3,2	14,0	51,1	22,6	0,27	
The same, under a rhodo- dendron fir	0-5	32,36	12,0	2,2	12,7	14,1	56,0	0,89	
	5-10	4,38	9,6	2,3	10,4	28,6	45,0	0,80	
	15-22	2,45	11,8	3,3	10,2	31,0	39,2	0,33	
	30-40	2,18	5,5	2,8	8,7	45,4	31,6	0,19	
Dark mountain-forest under a whortleberry-spruce, altitude 1800 m (6), Bul- garia	0-3	38,19	7,9	1,3	14,6	20,3	55,9	0,59	
	3-13	7,42	8,2	2,8	31,8	29,7	28,6	1,07	
	18-28	4,49	4,9	2,2	36,1	31,4	22,5	1,15	
	40-50	2,97	4,7	2,7	38,0	32,0	20,2	1,18	
Brown mountain-forest under a whortleberry-fir, altitude 1700 m (6), Bul- garia	0-2	33,78	20,3	0,9	4,9	14,2	59,2	0,26	
	2-10	2,84	8,0	1,7	19,1	32,6	38,6	0,59	
	15-25	1,81	7,7	2,8	16,6	32,0	40,9	0,52	
Strongly podzolic, whortle- berry-spruce, Vologod- skaya Oblast'	0-5	44,08	8,6	1,4	12,7	19,2	54,7	0,66	
	10-15	0,52	11,5	3,8	19,2	34,6	25,0	0,55	
	25-30	0,72	6,9	5,6	12,5	56,9	16,7	0,22	
	45-50	0,31	12,9	9,7	9,7	35,4	25,8	0,27	

Note: Comma represents decimal point.

soils so sharply that it is impossible to are them in any way.

er forest soils differ from the preceding by virtue of the predominance of fulvic in the composition of humus and of their bounds with iron, which may possibly be of their curd-like microaggregates. Com- of the waxy-resinous type, the amount of increases appreciably in the composition aus, may be of some significance in forma- of the latter.

is noteworthy that the proportion of C of mic acids to C of the fulvic acids in these s much lower than in the brown, dark, and ic soils. However, the mobility and ag- veness of the fulvic acids is less than in ls listed previously, as is shown by the at there is a smaller quantity of them in n B than in the spruce forest soils. How- the formation of a curdy microstructure ns the specificity of the fulvic acids,

which shows up in the positive effect it exerts on formation of the latter. Nevertheless, data on changes in the soils under question of the com- position of humus substances show that, given the similar nature of the organic residues out of which they are formed, their interaction with the mineral part in different climatic conditions results in the formation of soils with theoretical- ly different properties that determine the differ- ent types of soil formation to which they belong.

Besides the fact that they are formed in areas with different types of rock weathering, the interactions of the clay and organic matter are distinctly different.

In taiga soils these interactions lead to par- tial decomposition of the clay minerals and leaching of their products into the lower horizons and in brown mountain-forest soils to weak leaching of the clay substances into the lower horizons with slight decomposition. On the other hand, in dark and mountain soils of spruce

and fir forests the processes of humus accumulation by clay substances predominate.

Moreover, new minerals may possibly be synthesized in them along with intensified mobility of humus-iron compounds. Of greatest significance here is the pronounced alternation of periods of excessive moisture-anaerobiosis with optimum moisture conditions and aerobiosis. This is conducive to the transformation of part of the iron into divalent form and its leaching. However, at the same time the iron may be freed from the primary minerals, thus increasing the amount found in the top horizons. This may occur as a result of the leaching of SiO_2 and other compounds from them.

The difference in types of soil formation under dark coniferous forests in different climates is determined by the complex of factors enumerated.

Thus, the data cited are persuasive support for the view that the formation of various groups of soils under spruce and fir forests is closely connected with changes in biological and climatic factors, which determine the changes in development of the processes of soil formation. Furthermore, in Eastern Tibet soils formed under spruce and fir forests with characteristics and properties are so different from podzolic, brown, and dark mountain-forest soils as to warrant classifying them in a special group — mountain forest subtropical, with extensive accumulation of humus substances in the form of iron humates under spruce forests and iron fulvates under fir forests. These determine the subgroup differences.

The existence of some morphological podzolization in soils under fir forests, which does not accord with their distinct curdy micro-aggregate structure, is caused by the conversion of iron oxide compounds into ferrous oxides and their leaching into the lower horizons. However, there is no decomposition of clay minerals in the process nor any decrease in the exchange capacity of the soils, which rather indicates the manifestation of a pseudopodzolic quality in them.

Received March 6, 1960

BIBLIOGRAPHY

1. ANTIPOV-KARATAYEV, I. N. and I. P. GERASIMOV. 1948. Soils of Bulgaria. In the book: Reports on Bulgarian soil investigations undertaken by the Soviet-Bulgarian expedition of 1947. Sofia—Moscow. In Bulgarian and Russian.
2. GORBUNOV, N. I. 1956. Principles governing the occurrence of clay minerals in the main groups of USSR soils. In the book: Reports of the Sixth International Congress of Soil Science. Second commission—Soil Chemistry. Izd. Akad. Nauk SSSR. Moscow.
3. DOKUCHAYEV, V. V. 1949. Collected works. Vol. 3. Sel'khozgiz.
4. ZONN, S. V. 1957. Forest soils of Bulgaria. Izd. Akad. Nauk SSSR.
5. ZONN, S. V., A. GEORGIYEV, and Z. NAUMOV. 1959. Soil conditions in foothill regions of Kolarov and Shiroka Polyana. In the book: Organization in mountain stopanstvo. Published by Bulgarian Acad. Sci. Sofia. In Bulgarian.
6. ZONN, S. V., A. GEORGIYEV, Z. NAUMOV, and ZH. STOYANOV. 1958. Several questions on development of mountain-forest soils under spruce forest in Western Rodopakh. Published by Soil Institute of Bulgarian Acad. of Science. Book V. Sofia.
7. ZONN, S. V. 1959. Soils in Eastern Tibet and principles of distribution. Pochvovedeniye, No. 6.
8. PONOMAREVA, V. V. 1958. Nature and factors of soil formation. Pochvovedeniye, No. 9.
9. Soils of Bulgaria. 1947. Izd. Akad. Nauk SSSR. Moscow.

THE BIOLOGICAL CYCLE OF NITROGEN AND ASH ELEMENTS IN BOG FORESTS

I. P'YAVCHENKO, Institute of Forests and Woodlands, USSR Academy of Sciences, Leningrad

The biological cycle of nitrogen and ash elements in various types of bog forest is a subject of undoubted theoretical interest since it can help to reveal the essence of the interaction between medium and vegetation in forest and bog coenoses; it is also most important in connection with the drainage of forests and especially with the selection of areas for melioration and forest cultivation on drained bog soils.

The soil-plant biological cycle in non-bog forests has been studied by Remezov et al. (14), Remezov and Bykova (12, 13), Smirnova (15, 16), and others, but to the best of our knowledge no corresponding work has yet been done on swamped and bog forests.

In these, in contrast to non-bog forests, the regulation of nitrogen and ash elements is to a large extent peculiar, owing to the growth of the peat cover and the process of peat formation.

Our investigations were made in 1955-1957 at the Northern Forest Experiment Station of the Forest Institute of the USSR Academy of Sciences in the Kadnikov forest, Vologda region.¹ The groups of bog forest chosen for study were a broad-leaved spruce forest and a sphagnum pine forest. Both types are extremely peaty.

Sphagnum uliginosa-herbosa is widespread in the forest zone of the European part of the USSR, especially in the carbonate rock regions. It occurs in runoff depressions and gentle slopes where the subsoil not far below the surface is permeable to water and so makes for horizontal flow of the soil and ground waters.

We investigated two types of bog forest belonging to this group: the bog broad-grass spruce (test area No. 9 in the 23rd quadrat of the Kadnikovo forest) and the sphagnum-broad-leaved spruce (test area No. 7 in the 43rd quadrat of the same forest).

The former has a stand composition of 50% Spruce, 5 Birch, and a stand density of 0.5. The site quality is V; Age 100-150 years; total content of timber stand, 160 m³/ha.

From the field observations and chemical analyses were made mainly by Z. A. Sibirevaya.

The underbrush consists of junipers, buckthorn, cherry, various species of willow, honeysuckle, viburnum, black currant, rose and mezezon. The general crown density of the underbrush is 0.2.

Grass covers 60% of the area. The main grasses are *Filipendula ulmaria* and *Geum rivale*, Goutweed (*Aegopodium podagraria*), thistles (*Cirsium heterophyllum* and *C. arvense*), reedgrass (*Calamagrostis arundinacea* and *C. lanceolata*), ferns (*Dryopteris* sp.), horsetails (*Equisetum silvaticum* and *E. palustre*), geraniums (*G. palustre* and *G. pratense*), violet (*Viola epipsila* and *V. palustris*) are common. On elevated areas, wood sorrel, May lilies, mountain cranberry, and whortleberry grow at the foot of the trunks.

The moss cover, which occupies about 80% of the area, is composed equally of beds of green forest mosses (*Hilacomium proliferum*, *Pleurozium schreberi*, *Rhytidiadelphus triquetrus*) and such sphagnum species as *Sphagnum girgensohnii* and *S. warnstorfii*.

The soil is peaty and of lowland type, the peat layer being 125 cm thick. The upper 10 cm layer is a black lowland peat, moist, with a considerable amount of semi-decayed litter-fall strongly intermixed with live roots. The degree of decomposition is about 25%-30%.

The next layer (10-75 cm) is made up of wood peat (spruce and birch) of a dark cinnamon-brown color, decomposed to the extent of 45%-50% and in places more. Live tree and grass roots penetrate the greater part to a depth of 20 cm, where the peat is already completely saturated with water. At a depth of 75-100 cm there is sedge and wood peat of a dark brown color with a 30%-35% degree of decomposition. The bottom peat horizon is formed of hypnum low peat with a low degree of decomposition (about 15%).

Under the peat deposit is a half-meter layer of highly mineralized sapropel over gleyed clay loam.

The sphagnum broad-grass spruce has a stand composition of 9 Spruce, 1 Birch + Pine, and a stand density of 0.6. The site quality is V-Va; age 70-200 years; total content of timber stand, 203 m³/ha. The underbrush has developed in the

Table 1

Total nitrogen and ash contents in peaty soils

Forest type	Depth, cm	Ash	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	P ₂ O ₅	CaO	MgO	MnO ^a	K ₂ O	SO ₄ ^a	N
In % absolute dry weight												
Bog broad-grass spruce forest (test area No. 9)	0-10	10,75	2,62	0,96	0,98	0,28	4,18	0,52	—	0,19	—	3,03
	10-20	11,94	2,68	1,50	0,79	0,40	4,24	0,55	—	0,10	—	3,21
	20-25	11,08	2,21	1,95	0,61	0,40	4,05	0,51	—	0,08	—	2,79
Average		11,26	2,50	1,47	0,79	0,36	4,16	0,53	0,03	0,12	0,61	3,05
Content in 25 cm horizon, kg per ha, (bulk density of 0.111)												
		30965	6875	4142	2172	990	11440	1458	83	330	1678	8387
In % absolute dry weight												
Shrub-sphagnum pine forest (test area No. 2)	0-10	2,67	0,99	0,20	0,12	0,14	0,51	0,12	—	0,23	—	1,35
	10-20	3,87	1,84	0,35	0,17	0,16	0,57	0,11	—	0,16	—	2,07
	20-25	5,05	3,11	0,38	0,13	0,16	0,45	0,10	—	0,08	—	1,56
Average		3,86	1,98	0,30	0,14	0,15	0,51	0,11	0	0,16	0,29	1,66
Contents in 25 cm horizon, kg per ha, (bulk density of 0.066)												
		6484	3267	495	231	247	841	182	0	264	478	2744

^aDetermined in the 0-25 cm layer.

Note: Comma represents decimal point.

same way as in the case of the bog broad-grass spruce, except that here the juniper portion is appreciably larger.

Projective grass cover is 60%-70%. Formerly, the background for this consists of bog broad-grasses (coarse grasses) (spirea, geum, geranium and others), but sedge plays a more important part, forming small mounds. The depressions between these are in places filled with water, and bogbean, horsetail, rushes and other bog grasses grow here.

In the moss layer, 75% of the total area is taken up by sphagnum moss (*Sphagnum centrale*, *S. Girgensohnii* and *S. Warnstorfii*), while the green forest mosses listed above make up only 25% of the cover. Several species of bog hypnum mosses are found in the wet depressions.

As before, the soil is of the lowland peaty type. The total depth of the peat deposit is 175 cm. Morphologically its profile is similar to that of the bog broad-grass type and therefore will not be described here.

The characteristic feature of the bog-grass spruce group is the relative richness of the soil in total nitrogen and ash contents (Table 1). The presence of calcium carbonates in the soil in fairly large amounts and also, in part, of magnesium causes a neutral or near-neutral reaction of the soil water extract and gives it a high saturation in bases. The humus in these soils is mainly in the form of calcium humates.

The pines of the *Pineta sphagnosa* group are even more widespread than the bog-grass spruce especially in excess moisture regions. They

usually occupy flat depressions in watersheds and terraced bottom lands, where conditions are favorable for excess wetting of the soil by soft, mainly atmospheric, waters. Sphagnum pines are found also, although less frequently, in regions where carbonate rocks are common and waters are stagnant. In such cases the bog starts with a eutrophic stage, but as the peat layer builds up, isolating the plant root systems from the mineral subsoil, the eutrophic bog stage gives way to an oligotrophic, sphagnum stage.

In the Kadnikova forest lands, pine forests of the sphagnum group are not very common and are represented mainly by those of the shrub and sphagnum type. We investigated forests of this type in test area No. 2, 32nd quadrat. The stand composition here is 10 Pines with a stand density of 0.4; the site quality class is Va; age 10 years; standing timber content is 60 m³/ha.

There is no understory of forest trees. The grass- and shrub-cover are well developed. The total projective cover of grass and shrub is 60%. There are beds of wild rosemary (*Ledum palustre*) and leatherleaf (*Chamaedaphne corymbosa*) on the higher parts of the microrelief (hillocks, mounds around the trunk bases, mounds). *Andromeda polifolia*, *Oxycoccus dipetalus* and *Eriophorum vaginatum* are found in quantity everywhere.

The moss cover consists almost entirely of oligotrophic species of sphagnum (*Sphagnum balticum*, *S. angustifolium* and *S. fuscum*), and very small amounts of green forest moss (*Cladonia schreberi*) and wood lichen (*Cladonia silvatica*) and other growths on the tops of mounds and knolls. Soil is a peaty, surface layer. Total thickness of peat layer is 125 cm.

The 0 to 15 cm layer is made up of sphagnum material consisting of undecayed and semidecayed oligotrophic mosses with interturning of pine and shrub roots. The uppermost sphagnum peat, mixed with cotton grass residues, lies at a depth of 15-50 cm. This layer is water-saturated, cinnamon-brown colored and 25% decomposed.

The 50-100 cm layer is also made up of surface sphagnum peat, decayed 50% or more, and containing many buried pine stumps. Under this is a shallow (25 cm) horizon of sphagnum peat with a low degree of decomposition, and still further down, a similar thickness of peat, passing into gleyed clay loam.

The peaty soil of the shrub-sphagnum pine forest is distinguished by high moisture content, low acidity (pH 3.6), non-saturation by water, low ash content and weak biological activity.

As Table 1 shows, the peaty soil of the bog and grass spruce forest is twice as rich in nitrogen content and nearly five times as rich in ash contents as that of shrub-sphagnum forest.²

The total chemical soil analysis was made by us to a depth of only 25 cm, because in non-eroded peaty soils this horizon is subject to the in-

fluence of the ash contents in the spruce-forest soil, calcium occupies first and silicon second place. There is a good deal of aluminum, iron, magnesium and sulfur. This is due to the seepage flow to the bog. The total phosphorous content in the soil is moderate and the potassium content is somewhat low.

In the pine-forest soil, silicon accounts for more than half the total ash elements, as is usual in surface bogs. Next comes calcium, but the content is not large. The content in most of the other ash elements is low, the values being appreciably lower than those given for the spruce-forest soil. Potassium contents are much the same in both soils.

Our method of investigation has much in common with that suggested by Bykova (1) and used by Remezov and his co-workers, but differs more or less substantially from that method in parts.

The total content of standing timber in m³ per ha were calculated in the test areas by the method used for forest evaluation purposes. The result was converted to absolute dry weight by multiplying by the volume density (0.38 for spruce, 0.57 for birch and 0.42 for pine [2, 9]). The figures for the branch, root and green weight of the spruce and birch in our work-region were produced by V. V. Smirnov, those for pine were taken from Pereygin (9). The current timber increment in the spruce forest was determined directly in the course of forest classification work (V. G. Karpov) and the branch and root increment by ourselves, using Smirnov's figures for the trunk-branch-root weight ratio. The current increment in the pine forest was determined from the tables for normal plantation growth, allowance being made for the site quality class and the stand density.

Allowance was made for forest litter-fall by using small boxes to catch the fall over areas of 1 m² each, five boxes being placed in each test area of 0.1 ha.

The grass yield of tops was worked out at the beginning of September on 2-4 test areas of 1 m² each in the main vegetation groupings of each type of forest. The tops were cut, dried and weighed, and the figures obtained per ha converted into percentages of the projective cover for the area in each vegetative grouping.

The annual moss increment was determined by measuring the green part of the plant, which was clearly marked off from the faded previous year's growth by a thin interlay of wood fall and bog shrub leaflets. The size of the plots varied according to local conditions from 20 x 20 cm to 50 x 50 cm. Annual growth of moss was separated from the total mass, dried and weighed. The amount of material was calculated on 1 ha basis.

The bog-bush annual increment was assumed,

influence of seasonal variations in the soil-and-ground-water level, and is therefore under more favorable aeration conditions and distinguished by considerable biological activity. The depth indicated can be taken as the limit of living tree, shrub and brush root penetration into the peat.

as a rough guide, to be 10% of the total amount of top growth. Although this does not seem to have been an overestimate, specific research on bog-bush growth is nevertheless essential.

Average samples of the wood, needles, leaves and litter-fall (by fractions) of the bog-bush, grasses and mosses were analyzed for total nitrogen and ash contents. We did not analyze the small tree roots and under-ground parts of the grass vegetation, but decided that Smirnova's figures (15) for the spruce composition most similar to spruce-forests of the bog-grass group could be used to obtain approximate computations.

In the papers by Remezov and co-workers it is assumed that the biological cycle of nitrogen and ash elements in forests consists in their being taken up from soil by the vegetation, part of these substances being retained in the annual increment and part being returned to the soil with the forest litter-fall and dying parts of the grasses.

This method of studying the biological cycle of substances has been criticized by Tyulin (18), and by Vinokurov and Tyurmenko (4), who later associated themselves with his opinion. The main grounds of criticism are that nitrogen and ash contents are returned to the soil not only with the litter-fall but also with the root secretions and dying parts of small roots, principally root hairs. This means that roughly ten times the quantity of nutrients calculated by Remezov and his co-workers is annually drawn into biological circulation. It is claimed that the considerable reduction in carbon, nitrogen and phosphorous content in the root-supplying horizon of the soil in the first half of summer proves this to be true. Although there are now several works on root atrophy (3, 5, 8, 21) the quantitative aspect of this question still needs further investigation.

The foregoing considerations do not invalidate the method of studying the biological cycle in forests used by Remezov et al. As Remezov himself has said in reply to Vinokurov and Tyurmenko (11), the method needs further working out and improvement, and this is now being done. We believe that the method can be used to determine with sufficient accuracy the quantities of nitrogen and ash contents retained in the annual increment of perennial plants and returned to the soil with the litter-fall and dying parts of plants under a crown-cover. The total amount of nitrogen and ash elements drawn into circulation cannot, of course, be fully accounted for by adding the amount retained in the annual increment to the amount returned with the litter-fall and the above-ground and underground parts of plants, since the intake of these substances by the soil with root secretions and dying small roots must also be taken into account; but no such method has yet been worked out.

The principle used for studying the biological cycle of nutrients by Tyulin (18), and by Tyulin and Shcherbin (19, 20), based on allowing for seasonal variations of carbon, total nitrogen and mineral nutrients in the soil, naturally deserves attention and further thorough work, but only side by side with a quantitative study of the nutrient uptake and return by the trees themselves.

The inferences drawn by Tyulin (18), and by Vinokurov and Tyurmenko (4) to the effect that the amounts drawn into biological circulation are at least ten times greater than those found by Remezov et al. are, in our opinion, mistaken. Clear examples of over-estimation in the values for nitrogen and phosphorous uptake in the biological circulation are given in Remezov's reply (11).

We ourselves adduce the following example. According to the 1956 observations, the total nitrogen content in the root-supplying (25 cm) layer of the peaty soil of the bog broad-grass spruce forest decreased from 3.06% to 2.44% between mid-June and the second half of July; converted to kg per ha, this gives 1724 kg or about 20% of the total N content in the layer. Since the total N content in peat is mainly in the form of semi-available organic compounds, not available to plants, there are no grounds for believing that the entire nitrogen content is used by plant roots. If we add the amount of nitrogen retained in the annual increment of the spruce forest to the amount returned with litter-fall and the dying above-ground and underground parts of all the forest vegetation, we get only about 43 kg per ha, or about 2.5% of the total N loss given above. The available (ammonium) N content decreased during this period from 9.7 to 0.7 mg per 100 g dry soil (from 27 to 2.5 kg per ha, on conversion). These values do not, of course, reflect the actual available nitrogen uptake, since nitrogen is accumulating in the soil at the same time as it is being consumed. They do nevertheless give an idea of the order of magnitude of the nitrogen uptake by the plants. It must therefore be admitted that the reasons for the appreciable summer decrease in the total nitrogen content of peaty soil needs specific investigation.

Turning now to the results of our investigation we shall first deal with the current increment of the vegetation mass in the main types of bog forest.

Table 2 shows that the current growth increment in the bog and grass spruce forest is less than that of the grass and moss vegetation. The implication of this becomes particularly clear on comparison with the values for nitrogen and ash elements retained in the annual increment. In the grass and moss (mainly sphagnum) increment, three times as much nitrogen and ash elements, four times as much calcium and potassium and even six times as much magnesium is retained as in the increment of the trees. In the shrub and sphagnum pine forest the current growth increment was sixteen times less than that of the sphagnum moss cover. The difference is even greater if one compares the nitrogen and ash element content in the growth increments.

The phenomenon as noted previously is due to the fact that in our stands, consisting of very old trees, the current growth increment is negligible. In the case of younger stands, however, where the growth increment is three to four times greater, the importance of the moss cover emerges quite clearly.

It should be remembered, however, that whereas the nitrogen and ash elements in the tree

BOG FORESTS

Table 2

Annual growth increment and ash element content of vegetative mass in bog forest soils (in kg per ha)

Vegetation	Absol. dry mass	In absolute dry matter										
		N	Ash	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	P ₂ O ₅	CaO	MgO	MnO	K ₂ O	SO ₃
Bog and grassy spruce forest, Test area No. 7												
Spruce and birch stand	850	2,76	9,32	0,66	1,25	0,15	0,64	2,47	0,52	0,28	1,11	1,34
Undergrowth (arbitrarily taken as 10% of its dying part)	8	0,06	0,33	0,01	0,004	0,001	0,01	0,09	0,01	0,002	0,01	0,01
Grass cover (perennial grass roots - 10% of root mass)	89	1,44	3,43	0,16	0,41	0,03	0,46	0,77	0,37	0,05	1,11	0,39
Moss (green moss and sphagnum) cover	959	8,34	30,11	5,47	1,44	0,86	1,53	10,45	3,16	0,29	4,31	2,88
Total	1906	12,60	43,19	6,30	3,14	1,05	2,64	13,78	4,06	0,62	6,54	4,62
Low shrub and sphagnum pine forest, Test area No. 2.												
Pine stand	104	0,25	1,04	0,17	0,08	0,01	0,04	0,33	0,06	0,01	0,14	0,12
Small shrubs and cotton grass	15	0,27	0,26	0,01	0,01	0,004	0,03	0,05	0,02	—	0,06	0,04
Sphagnum cover	1661	13,73	37,04	7,64	3,32	1,99	2,32	6,31	3,48	—	8,60	4,82
Total	1780	14,25	38,34	7,82	3,41	2,00	2,39	6,69	3,56	0,01	8,80	4,98

Note: Comma represents decimal point.

Table 3

Variation in nitrogen and ash element content in sphagnum moss in proportion to peat formation from small shrub and sphagnum pine forest (in percentages)

Sample	In absolute dry weight									
	N	Ash	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	P ₂ O ₅	CaO	MgO	K ₂ O	
Living sphagnum moss	0,83	2,24	0,44	0,20	0,13	0,14	0,40	0,21	0,52	
Sphagnum peat										
" 0 - 10 cm	1,35	2,67	0,99	0,20	0,12	0,14	0,51	0,12	0,23	
" 10 - 20 cm	2,07	3,87	1,84	0,35	0,17	0,16	0,57	0,11	0,16	

Note: Comma represents decimal point.

Table 4

Annual deposition of decayed organic matter, nitrogen and ash content in bog forests (average for 2 years) (kg per ha)

Vegetation material	Absolute dry mass	In absolute dry weight										
		N	Ash	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	P ₂ O ₅	CaO	MgO	MnO	K ₂ O	SO ₂
Bog and grass spruce forest (average of 2 test areas)												
Spruce needles	555	4,22	29,47	7,60	1,94	0,33	0,61	10,65	0,55	0,33	1,83	1,05
Birch leaves, etc.	930	8,93	41,10	1,49	3,07	0,74	0,96	21,48	3,81	1,20	1,02	1,95
Twigs, bark, cones	495	2,92	9,99	1,04	0,99	0,15	0,30	4,69	1,14	0,25	0,74	0,69
Deadwood and brushwood	1140	2,74	11,51	0,91	1,06	0,09	0,51	2,96	0,68	0,17	1,25	0,68
Dead roots of tree vegetation (taken as 10% of needle and leaf fall)	148	1,09	2,69	0,13	0,59	0,09	0,35	0,77	0,12	0,04	0,35	0,25
Total for the tree	3268	19,90	94,76	11,17	7,65	1,40	2,73	40,55	6,30	1,99	5,19	4,62
Litter-fall and dead roots	77	0,92	2,77	0,10	0,15	0,05	0,14	1,25	0,23	0,04	0,39	0,11
Grass cover with dead part of roots (taken as 10% of root mass)	622	9,45	48,08	8,27	3,30	0,25	1,80	13,12	3,92	0,43	11,07	4,98
Annual cover of dead green and sphagnum moss ^a	671	5,83	21,05	3,82	1,00	0,60	1,07	7,30	2,22	0,20	3,02	2,01
Total	4638	36,10	166,66	23,36	12,10	2,30	5,74	62,22	12,67	2,66	19,67	11,72
Low shrub and sphagnum pine forest												
Pine needles	552	1,99	12,14	0,66	0,44	0,11	0,30	5,52	1,10	0,44	0,94	1,60
Twigs, bark, cones	145	0,59	3,50	0,30	0,39	0,04	0,10	1,36	0,09	0,01	0,23	0,20
Dead pine roots (taken as 10% of needle fall)	55	0,22	1,33	0,11	0,11	0,02	0,04	0,52	0,03	0,01	0,08	0,07
Deadwood and brushwood	406	0,61	2,72	0,24	0,19	0,03	0,29	0,69	0,26	0,04	0,57	0,49
Total for the tree	1158	3,41	19,69	1,31	1,13	0,20	0,73	8,09	1,48	0,50	1,82	2,36

^a The nitrogen and ash element content were calculated from the analysis values for the living moss cover, since no analysis was made for the dead part of the mosses in the spruce forest.

Note: Comma represents decimal point.

BOG FORESTS

Table 4 (continuation)

Vegetation	Absolute dry mass	In absolute dry weight										
		N	Ash	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	P ₂ O ₅	CaO	MgO	MnO	K ₂ O	SO ₃
Low shrub and cotton grass litter-fall with dead part of roots	150	1,44	2,87	0,59	0,08	0,04	0,29	0,59	0,27	—	0,61	0,45
	1156	15,60	30,86	11,44	2,31	1,39	1,62	5,90	1,39	—	2,66	3,35
Total	2464	20,45	50,55	13,34	3,52	1,63	2,64	14,58	3,14	0,50	5,09	6,16

Note: Comma represents decimal point.

canopy, underbrush, bog low shrub and perennial part of the grass vegetation increments accumulate throughout the life time of the plants, no such accumulation occurs in the sphagnum moss cover. It is known that sphagnum moss grows in its upper part, the lower part dying off to form peat. Part of the nutrients, particularly the readily available part, moves upwards, following the growth of the moss. The nitrogen and ash elements contained in the living part of growing sphagnum moss should therefore be regarded as substances used in the life process of the moss cover rather than as substances retained in the increment.

Our investigations showed that the weight of the dying part of the sphagnum moss was only 70% of the weight of the living part (in dry condition). The nitrogen and ash element content in the dying part also varies, as Nikinov has noted (7) and as we established from our investigations in the Vologda region.

From Table 3 it can be seen that as the sphagnum turns into turf, the nitrogen and ash element content in it increases, with the exception of magnesium and potassium. The increase in N content may be due partly to the activity of microorganisms and ammonia fixation by the semidecayed sphagnum itself and partly to the availability of N from root secretions. The enrichment of the peat with ash elements must be attributed to their release through organic decay and return to the soil with root secretions and atmospheric dust. The importance of dust in bog nutrition was noted in (10). The maximum content in magnesium, and particularly in potassium, is in the growing part of the moss, to which solutions of these substances migrate from the dying lower part.

If we now take the values which include allowance for organic matter, nitrogen and ash elements brought in with the organic matter annually returned to the soil in the form of litter-fall and dying plant organs above-ground and underground (Table 4), we find, first, that the amounts of such material, including nitrogen and ash elements, reaching the spruce-forest soil in the course of the year are much greater than the amounts reaching the soil under shrub and sphagnum pine forest. This is obviously due to a difference in the water nutrition regime of the bogs and the richness of the peaty soil which is a function of this. It follows that in the bog and grass spruce forest, about 72% of the organic matter comes in with the litter-fall from the tree stand and the underbrush, although the nitrogen and ash elements in it make up only a little over half the total accumulation. Nearly half the ash is calcium and magnesium, and there is a good deal of silica and aluminum.

About 42% of all the nitrogen and ash is contained in the organic mass of dead grasses and of green and sphagnum mosses, which is considerably less, in terms of weight, than that of the tree litter-fall. Again calcium is the main ash element, followed by potassium and then silicon.

In the shrub and sphagnum pine forest the amount of organic matter entering the soil with the tree litter-fall and the dying parts of the grass, shrub and moss cover is roughly the same but the nitrogen amount in the latter is 1.6

Table 5

Biological cycle of nitrogen and ash elements in bog forests (kg per ha)

Substance	Trees and undergrowth			Grass and low-shrub cover			Moss cover			Total		
	Uptake	Retention	Return	Uptake	Retention	Return	Uptake	Retention	Return	Uptake	Retention	Return
Bog-grass spruce fores												
N	23,64	2,82	20,82	10,89	1,44	9,45	8,34	2,51	5,83	42,87	6,77	36,10
SiO ₂	11,94	0,67	11,27	8,43	0,16	8,27	5,47	1,65	3,82	25,84	2,48	23,36
Al ₂ O ₃	9,05	1,25	7,80	3,71	0,41	3,30	1,44	0,44	1,00	14,20	2,10	12,10
Fe ₂ O ₃	1,60	0,15	1,45	0,28	0,03	0,25	0,86	0,26	0,60	2,74	0,44	2,30
P ₂ O ₅	3,52	0,65	2,87	2,26	0,46	1,80	1,53	0,46	1,07	7,31	1,57	5,74
CaO	44,36	2,56	41,80	13,89	0,77	13,12	10,45	3,15	7,30	68,70	6,48	62,22
MgO	7,06	0,53	6,53	4,29	0,37	3,92	3,16	0,94	2,22	14,51	1,84	12,67
MnO	2,31	0,28	2,03	0,48	0,05	0,43	0,29	0,09	0,20	3,08	0,42	2,66
K ₂ O	6,70	1,12	5,58	12,18	1,11	11,07	4,31	1,29	3,02	23,19	3,52	19,67
SO ₃	6,08	1,35	4,73	5,37	0,39	4,98	2,88	0,87	2,01	14,33	2,61	11,72
Shrub and sphagnum pine forest												
N	3,66	0,25	3,41	1,71	0,27	1,44	13,73	—	15,60	19,10	—	20,45
SiO ₂	1,48	0,17	1,31	0,60	0,007	0,59	7,64	—	11,44	9,72	—	13,34
Al ₂ O ₃	1,21	0,08	1,13	0,09	0,01	0,08	3,32	1,01	2,31	4,62	1,10	3,52
Fe ₂ O ₃	0,21	0,01	0,20	0,044	0,004	0,04	1,99	0,60	1,39	2,24	0,61	1,63
P ₂ O ₅	0,77	0,04	0,73	0,32	0,03	0,29	2,32	0,70	1,62	3,41	0,77	2,64
CaO	8,42	0,33	8,09	0,64	0,05	0,59	6,31	0,41	5,90	15,37	0,79	14,58
MgO	1,54	0,06	1,48	0,29	0,02	0,27	3,48	2,09	1,39	5,31	2,17	3,14
MnO	0,51	0,01	0,50	—	—	—	—	—	—	0,51	0,01	0,50
K ₂ O	1,96	0,14	1,82	0,67	0,06	0,61	8,60	5,94	2,66	11,23	6,14	5,09
SO ₃	2,48	0,12	2,36	0,49	0,04	0,45	4,82	1,47	3,35	7,79	1,63	6,16

Note: Comma represents decimal point.

times, and the ash amount five times that in the litter-fall. Just as in the spruce forests, about half the litter-fall ash is made up of calcium and magnesium. The amount of silicon and aluminum is negligible. There is much more nitrogen and ash in the annual mass of dying sphagnum moss than in the litter-fall, silicon being the main element, instead of calcium, as in the bog spruce forests.

Having determined the extent of retention and return of nitrogen and ash elements in the bog-grass spruce forest and shrub-sphagnum pine forest, we can now describe the annual cycle of biological circulation in these forests (Table 5).

We are treating the biological nitrogen and ash element cycle first separately for the three vegetative groups: 1) the standing timber and undergrowth; 2) the grass and shrub cover; 3) the moss cover; and then for the bog forest as a whole. The main components of the cycle are: extraction of substances from the soil by vegetation ("uptake" column), fixation of some of these substances to the organic mass increment ("retention" column) and their return to the soil with the dying parts of plants ("return" column). In the case of the moss cover, the uptake of sub-

stances was taken as equal to the living (annual) sphagnum mass content in those substances, as the growth and death characteristics of moss, mentioned previously, indicate.

It follows from the values given in Table 5 that in the bog-grass spruce forest, about 88% of the nitrogen used and 79%-98% of the main ash elements are returned to the soil by the standing timber, undergrowth and grass cover, and about 70% of the substances used are returned by the moss cover. In the spruce forest as a whole, however, only 84% of the nitrogen and 78%-90% of the ash elements are returned. The element returned in smallest quantity is phosphorus; this seems to indicate a lack of available phosphorus in the soil. In the shrub and sphagnum pine forest the tree and shrub canopy returns roughly the same percentages of nitrogen and ash elements as are used, but the picture is different in regard to the sphagnum-moss cover: 14% more nitrogen, 50% more silicon, about 93% more calcium, 40% more magnesium and only 31% more potassium enter the soil than are taken up. Nearly 70% of the uptake of other elements is returned. In the shrub and sphagnum pine forest more nitrogen and silicon enters the soil than is taken up, about half the amount of

assium and magnesium and 73%-95% of the other elements.

The high nitrogen and silicon uptake in comparison with requirements must be due partly to secretions from tree and shrub suctorial roots spreading through the region of dying sphagnum, and partly to the accumulation of potassium and other elements from the atmosphere.

The data we have examined here relate to an overmatured bog forest, in which the current growth increment is negligible, with the result that little nitrogen and ash is retained. This forest can be regarded as typical of most forests in the taiga zone. They are not usually growing due to the small timber content they contain and the difficulty of logging the timber under bog conditions. Most of the trees, therefore, belong to VI to VIII age classes or are even older. Replacement of timber in these forests is mainly in the form of new growth in places where overmatured trees are dying off, since this is a slow and a gradual process. Particularly in the spruce forests, the character of the bog forests hardly varies at all.

Conclusions

1. The biological cycle of nitrogen and ash elements in bog forests has peculiar characteristics, in comparison with dry types of forests. This is due to the regular growth of a moss cover and the development of a peat-forming process.

2. In bog-grass spruce forests 100-200 years old the current (annual) growth increment is less in mass and particularly in nitrogen and ash content than the grass and moss cover increment; in the latter, three times more nitrogen and ash, four times more calcium and potassium and six times more magnesium is retained than in the tree growth increment.

3. In the 120-year-old shrub and sphagnum pine forest, the current growth increment in the pine is sixteen times less than the annual sphagnum increment. The difference is still greater in regard to nitrogen and ash content in the new growth of moss.

4. About 84% of the nitrogen and 78%-90% of the ash contents are returned to the soil by the trees, undergrowth and grass, shrub and moss cover in the bog-grass spruce forests. In the shrub and sphagnum pine forest the vegetation retains more nitrogen and silica (in terms of amounts retained in the increment plus amounts returned to the soil) than it takes up, about half the amount of potassium and magnesium and 73%-95% of the other elements.

5. The nitrogen and ash (other than magnesium and potassium) enrichment of the sphagnum peat formed can be explained, first, by the return of these substances to the soil in root secretions, and secondly by the fixation of atmospheric nitrogen by microorganisms and by undecomposed sphagnum peat itself, the ash increase being a consequence of organic decay and the deposition of atmospheric dust.

BIBLIOGRAPHY

1. BYKOVA, L. N. 1951. Methods of work on the study of nitrogen and ash element cycle in forest biocoenoses. *Pochvovedeniye*, No. 1.
2. VANIN, S. I. 1949. *Wood science*. Goslesbumizdat, Moscow-Leningrad.
3. VERETENNIKOV, A. V. 1959. Atrophy and regeneration of the root system of *Pinus silvestris* L., depending on the conditions of atmospheric oxygen supply to the root layer of the soil. *Botan. zh.*, No. 2.
4. VINOKUROV, M. A. and A. N. TYURMENKO. 1958. Data on the biological cycle of nitrogen and phosphorus in forests. *Pochvovedeniye*, No. 7.
5. KOLESNIKOV, V. A. 1924. Aspects of atrophy in the root systems of tree species. *NAZh*.
6. MINA, V. N. 1955. Cycle of nitrogen and ash elements in steppe oak forests. *Pochvovedeniye*, No. 6.
7. NIKONOV, M. N. 1955. Origin and composition of forest zone peat ash. *Tr. In-ta lesa Akad. Nauk SSSR*, 26.
8. ORLOV, A. YA. 1955. The role of suctorial tree-roots and organic enrichment of soil. *Pochvovedeniye*, No. 6.
9. PERELYGIN, L. M. 1949. *Wood science*. Goslesbumizdat, Moscow-Leningrad.
10. P'YAVCHENKO, N. I. and Z. A. SIBIREVA. 1959. The role of atmospheric dust in bog nutrition. *Dokl. Akad. Nauk SSSR*, 124, No. 2.
11. REMEZOV, N. P. 1959. Methods of studying the biological cycle of elements in the forest: reply to M. A. Vinokurov and A. N. Tyurmenko. *Pochvovedeniye*, No. 1.
12. REMEZOV, N. P. and L. N. BYKOVA. 1952. Utilization and cycle of nutrient elements in an oak forest. *Vestnik MGU (State University of Moscow)*, No. 6.
13. REMEZOV, N. P. and L. N. BYKOVA. 1953. Utilization and cycle of nitrogen and ash elements in aspen forests. *Pochvovedeniye*, No. 8.
14. REMEZOV, N. P., K. M. SMIRNOVA, and L. N. BYKOVA. 1949. Some conclusions from studying the role of forest vegetation in soil formation. *Vestnik MGU (State University of Moscow)*, No. 6.
15. SMIRNOVA, K. M. 1951. The nitrogen and ash element cycles in mixed-fir stands. *Vestnik MGU (State University of Moscow)*, No. 10.
16. SMIRNOVA, K. M. 1952. Utilization and cycle of nutrient elements in the Mordovo State Park basswood forest. *Vestnik MGU (State University of Moscow)*, No. 6.

17. TRETYAKOV, N. V., P. V. GORSKIY, and V. YE. SHUL'TS. 1940. Forest evaluator's handbook. Goslestekhzdat, Leningrad.
18. TYULIN, A. F. 1954. Method of studying plant-soil mineral exchange in forests. Tr. In-ta lesa Akad. Nauk SSSR, 23.
19. TYULIN, A. F. and K. G. SHCHERBINA. 1954. The biological plant-soil cycle of nitrogen and phosphorus in the broadleaf forests of the southern part of the forest-steppe throughout the growing period. Dokl. Akad. Nauk SSSR, 97, No. 1.
20. TYULIN, A. F. and K. G. SHCHERBINA. 1955. Mineral nutrition of the oak in Tellerman experimental forestry. Tr. In-ta lesa Akad. Nauk SSSR, 24.
21. HEIKHURAINEN, LEO. 1957. Ueber Veränderungen in den Wurzelverhältnissen der Kieferbestände auf Moorboden im Laufe des Jahres. Acta forest, fenica, 65. In German

SEASONAL CHANGES IN THE HUMUS AND NITROGEN CONTENT OF SHALLOW CHERNOZEMS IN FOREST PLANTATIONS¹

F. SOKOLOV, Laboratory of Forestry, Academy of Sciences, USSR

Many investigators (1, 2, 5, 6, 8, 9, 10, 14, 15, 18, 19, 24, 25) have studied seasonal changes in the available forms of nutrients and in total content of biogenic elements in forest soils. These changes largely depend on weather conditions (precipitation, air and soil temperature) which have great influence on transformation of organic matter in the forests.

Fehér (25) in a study of Hungarian forest soils found that September and May-June are months of maximum and minimum content, respectively, of humus in the humus-accumulation horizons (without litter). Under spruce, fir, and larch growing in sandy clay loams on loess, the annual fluctuation is from 1.5% (May) to 1.15% (September), the average content being 1.22%.

M. M. Abramova (1) noted substantial seasonal changes in the humus content of podzolic soils in the Central National Forest. These changes are due to two things: a) decomposition and mineralization of organic matter, and b) replenishment of the soil horizons with the products of decaying plant residues (litter, root exudates).

S. V. Zonn and A. K. Aleshina (5), like Abramova, found a double-peak humus curve in dark-gray forest soil and residual podzolized solonetz (Tellermanov Experimental Forest). For example, in horizon A₁' of the upper and horizons A₀, A₁, and A₂B₁ of the lower solonetz decreases during the summer, increases early in autumn, and once again decreases. This is evident from the following comparative data for subhorizon A₁' of dark-gray forest soil. If the amount of humus in the soil as in June is taken as 100%, the changes were as follows:

	June	July	Aug.	Sept.	Oct.
Humus, %	26	21	30	25	28
27a	7.99	8.11	10.29	7.35	6.49
27b	77.8	79.0	100.2	71.6	63.2

The numerator represents the percentage of humus in dry soil.

The work was done under the general direction of S. V. Zonn.

The decrease in humus in the 10 cm layer of the soil under investigation, when converted to hectares, amounted to 15.5 metric tons of organic matter for 16 days (from June 10 to 26).

Humus dynamics, according to the authors of the article, varies with the meteorological conditions. Periodic rain helps to decompose litter and leach out the available forms of organic matter which then accumulate in the humus horizons. Changes in humus dynamics correlate well, according to their data, with the dynamics of litter decomposition and availability of its water-soluble products of decomposition.

However, Mina (13), after examining their material, concluded that major changes in humus and nutrient content are in all probability due to the great diversity of ways in which the individual components are distributed in forest soils.

We must also mention the even more substantial seasonal changes in carbon and nitrogen content noted by Tyulin (17) in dark-gray forest soil (25-year old oak stand of the Tellermanov Experimental Forest of the Forest Institute, Academy of Sciences USSR). Tyulin linked variations in the amount of biogenic elements to the cycle of substances during the period of maximum growth of oak and the vegetation associated with it.

The sharp changes in the humus and nitrogen content of forest soil during the growing period are evidently attributable not only to the biological cycle of substances, but also to the method of obtaining average soil samples for analysis.

We should like to point out that we (16) studied the group and fraction composition of humus in the same soils using Tyurin's method (23). Our analysis revealed that the carbon content of the nonhydrolyzable residue in subhorizon A₁' of dark-gray forest soil is 49.2% while the content of nitrogen comes to 53.7% of the total content. Substances soluble after decalcification constitute for carbon only 4.15% and for nitrogen 3.93% of their total content in the soil.

Thus, the complex of humus substances in dark-gray forest soils is very stable bio-

chemically so that sharp changes in the content of biogenic elements during the growing period can hardly be expected.

M. A. Vinokurov and A. N. Tyurmenko (2) used Tyulin's method to study the dynamics of biogenic elements in moderately podzolic soils under pine and birch plantations and obtained somewhat smaller changes in the humus and nitrogen content. For example, in Tyulin's experiments the loss of carbon in the soil for this period of time was 66%-34%, whereas it was 34%-22% in the experiments of Vinokurov and Tyurmenko. The loss of nitrogen in Tyulin's experiments ranged from 44% to 35%, whereas it was 28%-22% in the experiments of Vinokurov and Tyurmenko. Organic matter in the moderately podzolic soils investigated by Vinokurov and Tyurmenko was much more mobile than in dark-gray forest soils. There was much less change in humus and nitrogen content than in Tyulin's experiments because the soil samples were obtained more carefully.

Thus, data on seasonal changes in the carbon- and nitrogen-containing substances of various groups of soils shows the marked dynamic quality of these substances as a result of weather conditions and, to a lesser degree, to the method of obtaining soil samples for analysis.

To check some of the findings in the works referred to, we undertook an investigation of seasonal changes in the biogenic elements of shallow chernozems in forest stands and the area in between on the Derkul Research Station of the Institute of Forests, Academy of Science, USSR, located in the northwestern part of Lugan Oblast¹ on a slope of the Derkul-Kamyshnaya River watershed.

Soil-forming parent material is represented here by yellowish-brown loess-like clay loam. The climate in the Derkul Station region is that of a zone of irregular precipitation. The mean annual rainfall is 419 mm, mostly during the spring and summer months. During the period of our observations of the dynamics of humus and nitrogen 220.9 mm of rain or 52.7% of the annual total, fell on the oak plantation (Block 50) distributed by months as follows: April, 40.0 mm; May, 21.8; June, 69.0; July, 48.1; August, 42.0.

Average soil samples for laboratory analysis and determination of soil moisture at the time taken were obtained with a soil auger at three depths (0-10, 10-20, and 30-30 cm) at six points arranged in a definite order on each plot. A total of nine plots were investigated of which eight were under trees while the ninth was an area between plantations 200-m wide under winter wheat. Soil samples of the latter were obtained from the center. Data on soil moisture at the time the samples were taken for analysis are presented in Table 1.

The moisture content in the humus horizons during the observation period varied considerably. The soil was driest in July and September, more so on the treeless plot in July than on the others. The reverse proved to be the case in September. On Plot No. 6, previously occupied by wheat, the moisture content was higher than on the tree plantations. On the

latter, despite the marked decrease in rate of transpiration of the trees, the soil became drier, especially on the plots with well developed growth of Siberian acacia (Plot No. 1) and on a plot with a canopy of thinned oak heavily overgrown with grass (Plot No. 9).

The soils can be subdivided into three groups with respect to total humus content² (Table 2). The first group includes plot Nos. 4, 5, and 7 under oak, ash, and elm planted in 1903-1904. The second includes three plots (Block 50, Plot Nos. 1, 2, 3) and the area between stands (Plot No. 6). The third group includes two wooded plots (Block 51, Plot Nos. 8 and 9) with low humus content in the 30 cm layer of the humus-accumulative horizon (average humus content <5% in the 0-30 cm layer).

Changes in the total humus content during the growth period were insignificant. There is some tendency for it to decrease from spring to fall, except on two plots (Nos. 6 and 8) where it increases somewhat by fall at a depth of 10-20 and 20-30 cm.

The maximum deviations (isolated) in the seasonal dynamics of humus substances range from -27.5% to +24.7% of the initial content (May 17). The greatest changes during the growing season take place in the top 10 cm layer, i.e., in the layer in direct contact with the bottom of the litter. These changes in relative content of organic matter are due not only to decomposition, consumption or synthesis (accumulation,) but also to some mechanical redistribution as a result of the activity of burrowing soil vertebrates and invertebrates (3, 4, 7). The role of the latter in this complex transformation of organic matter is fairly large, particularly in the zone where the litter comes in contact with the soil. With depth the activity of the animals tends to decrease so that there is also a seasonal drop in the humus content. This is vividly shown by the data on dynamics of relative humus content of the 30 cm layer (Fig. 1).

The greatest loss of humus during the observation period was noted in mid-September on Plot Nos. 3 and 4, i.e., in soil with increased content of organic matter (6.42% and 7.68% humus). A deviation of a little over 10% in maximum humus loss from the mean arithmetic value determined during the observation period (Table 3) occurred on only one of the nine Plots (No. 4).

On Plot No. 5, where the trees and undergrowth had been thinned out before, there was some increase in the rate of decay and mineralization of organic matter (a loss of 18.8%) as a result of, in all likelihood, considerable moisture and greater warming of the top layers of the soil because the tree crowns were less crowded.

The reduction in humus content of the soil on this plot is a continuous process from spring to fall, from 8.53% (May 17) to 6.92% (September 16), although no marked differences in

² Tyurin's method was used to determine the humus (20).

HUMUS AND NITROGEN CONTENT

Table 1

Soil moisture at the time samples were obtained for analysis (growing season of 1955) as a % of absolutely dry soil

Plantation land use	Plot No.	Composition	Depth, cm	Time soil samples obtained				
				May 17	June 16	July 15	Aug. 16	Sept. 16
Forest stand, Block 50, unit 5 (former Block 27); age class I, density 0.8	1	Oak, ash, Siberian acacia	0-10	20,2	33,9	15,2	22,2	12,9
			10-20	24,5	26,9	17,5	21,9	13,9
			20-30	25,6	24,2	21,4	17,4	14,7
	2	Oak, ash (acacia cut)	0-10	20,3	31,6	16,7	24,5	12,4
			10-20	27,6	25,3	18,1	18,9	15,1
			20-30	25,0	23,0	20,5	20,0	15,7
	3	Oak (ash and acacia cut)	0-10	18,9	30,7	17,2	27,1	13,1
			10-20	20,5	25,8	18,9	24,1	15,6
			20-30	21,7	25,3	22,7	22,7	16,1
Forest belt, Block 51, unit 4 and 5 (former forest belt 77); age of plantation 52 years	4	Oak, ash, elm	0-10	18,4	34,9	16,8	26,1	13,4
			10-20	23,9	26,9	20,0	23,6	15,7
			20-30	30,2	23,8	28,0	21,8	15,2
	5	The same (selective cutting)	0-10	26,9	31,4	18,2	25,8	18,1
			10-20	23,5	27,4	21,6	26,1	18,1
			20-30	26,9	22,7	20,0	23,9	18,3
Area between former forest belts 77 and 80	6	Winter wheat	0-10	13,9	26,7	13,9	30,4	17,1
			10-20	16,5	17,1	14,5	29,4	20,3
			20-30	25,6	17,6	14,8	28,0	21,6
Forest belt, Block 51, unit 1 (former forest belt 80); age of plantation 52 years	7	Oak, ash, elm	0-10	25,6	25,8	17,1	27,4	15,6
			10-20	25,0	25,6	19,0	24,1	16,1
			20-30	23,8	25,6	25,4	17,6	15,7
Forest stand, Block 47, unit 7 (former Block 25); age class III, age of planting 25 years	8	Oak (dense plantation)	0-10	21,7	30,5	18,9	24,2	13,5
			10-20	23,5	29,3	18,1	18,6	15,5
			20-30	23,6	23,9	18,2	16,7	15,5
	9	The same (thinned plantation)	0-10	20,8	32,5	18,9	24,7	12,8
			10-20	20,2	29,0	18,5	21,9	13,2
			20-30	26,6	24,4	17,8	17,2	14,8

Note: Comma represents decimal point.

Humus content were observed between the last and the samples were taken.

The seasonal dynamics of humus revealed in the top layer of soil on wooded and treeless plots is included in the values of the deviations from the mean arithmetic indices permissible for experimentation. Thus, the maximum deviations in humus loss range from 18.8%-2.4%, on average of 8.9% for the entire series of plots. The maximum losses of humus during the entire growing season, as shown by column 9 of Table 3, deviate 6.2% from the mean values.

The loss of organic matter in shallow chernozems during the 1955 growing season does not exceed their content of readily hydrolyzable forms of humus substances³ (Table 2, column c). The readily hydrolyzable forms of organic matter in the 30 cm layer of soil on the nine tracts averages 11.4% of the total carbon content. The amount may serve as an indicator for judging deviations in the seasonal dynamics of humus content of soils with a relatively stable

nozemz during the 1955 growing season does not exceed their content of readily hydrolyzable forms of humus substances³ (Table 2, column c). The readily hydrolyzable forms of organic matter in the 30 cm layer of soil on the nine tracts averages 11.4% of the total carbon content. The amount may serve as an indicator for judging deviations in the seasonal dynamics of humus content of soils with a relatively stable

³ The method of Tyurin and Kononova (21, 22) was used to determine the readily hydrolyzable forms of humus and nitrogen.

Table 2

Dynamics of content of total humus and its readily hydrolyzable forms in shallow chernozem during the 1955 growing season

Plot No.	Depth, cm	Time soil samples obtained for analysis										
		May 17			June 16	July 15			Aug. 16	Sept. 16		
		a	b	c		a	b	c		a	b	c
1	0-10	5,96	0,81	13,6	6,93	5,27	0,77	14,6	5,37	5,54	0,74	13,4
	10-20	5,20	0,76	14,6	4,52	4,99	0,63	12,7	5,06	4,87	0,68	14,0
	20-30	4,37	0,69	15,8	4,42	4,78	0,77	16,1	4,77	4,25	0,57	13,4
2	0-10	6,32	0,78	12,3	6,20	5,94	0,56	9,4	5,80	5,91	0,79	13,4
	10-20	5,75	0,66	11,5	5,39	5,46	0,64	11,7	5,46	5,41	0,81	14,9
	20-30	5,08	0,69	13,6	4,82	4,84	0,57	11,9	5,09	5,01	0,73	14,6
3	0-10	5,98	0,93	15,6	4,42	5,63	0,76	13,5	5,84	6,03	0,78	12,9
	10-20	5,54	0,76	13,7	5,66	5,44	0,73	13,4	5,25	5,35	0,78	14,5
	20-30	5,15	0,77	14,9	5,16	4,87	0,75	15,4	4,73	4,90	0,76	15,5
4	0-10	7,10	0,75	10,6	8,86	7,56	0,72	9,5	7,41	6,55	0,55	8,4
	10-20	6,56	0,70	10,6	6,15	6,23	0,65	10,4	6,29	5,46	0,58	10,6
	20-30	5,66	0,57	10,0	5,61	5,70	0,50	9,1	5,68	4,82	0,55	11,4
5	0-10	10,22	0,90	8,9	10,33	8,15	0,64	7,8	7,70	7,41	0,45	6,1
	10-20	7,81	0,69	8,8	7,85	7,63	0,46	6,0	7,24	6,94	0,52	7,5
	20-30	7,58	0,60	7,9	6,58	7,08	0,53	7,5	6,01	6,41	0,61	9,5
6	0-10	6,41	0,37	5,8	5,85	5,85	0,44	7,5	5,37	5,99	0,67	11,2
	10-20	5,56	0,49	8,8	5,60	5,70	0,32	5,4	5,37	6,03	0,47	7,8
	20-30	5,28	0,55	10,4	5,37	5,46	0,58	10,6	4,66	5,47	0,50	9,1
7	0-10	7,20	0,55	8,2	Not det'd.	8,25	0,90	10,9	7,69	7,03	0,72	10,2
	10-20	6,27	0,45	7,1	6,63	6,61	0,56	8,5	6,25	5,79	0,69	10,2
	20-30	6,06	0,55	10,8	6,15	6,39	0,40	6,2	5,57	5,42	0,56	10,3
8	0-10	5,09	0,77	15,1	5,34	4,54	0,59	13,0	4,73	5,06	0,65	12,8
	10-20	4,56	0,57	12,5	4,58	4,35	0,67	15,4	4,25	4,66	0,64	13,7
	20-30	4,06	0,52	12,8	4,06	3,85	0,62	16,1	3,73	4,25	0,61	14,4
9	0-10	5,42	0,56	10,4	5,41	4,96	0,65	13,1	4,77	4,96	0,79	15,9
	10-20	4,56	0,62	13,6	4,56	4,73	0,65	13,7	4,33	4,14	0,57	13,8
	20-30	4,01	0,57	14,2	4,06	3,95	0,59	14,9	3,90	3,78	0,49	13,0

a — Humus content as a % of dry soil; b — content of readily hydrolyzable forms of humus as a % of dry soil; c — content of readily hydrolyzable forms of humus as a % of total humus in the soil.

Note: Comma represents decimal point.

organic mineral complex. Deviations may be in the direction of a relative decrease or increase. Deviations toward a reduction of humus substances during the growing period may not exceed the quantities of those substances capable of being hydrolyzed. Kuznetsov and his co-workers (11, 12) showed that microorganisms

use only those organic substances which break down into their constituent parts when heated with a normal solution of sulfuric acid. Hence, our figures on the content of readily hydrolyzable carboniferous compounds in shallow chernozem on the various tracts will be somewhat higher if more concentrated sulfuric acid

HUMUS AND NITROGEN CONTENT

Table 3

Loss of humus in the 0-30 cm layer of shallow chernozem between May 17 and September 16, 1959

Plot No.	Maximum loss of humus as a % of	
	its initial content	mean values during observation per
1	5,8	4,0
2	2,4	1,1
3	2,6	3,8
4	15,6	2,6
5	18,8	9,9
6	10,8	8,4
7	6,6	6,4
8	7,5	5,4
9	8,0	4,7

Note: Comma represents decimal point.

0 N) is used for hydrolysis. The resultant indicators of content of readily hydrolyzable substances may well be the maximum deviations in the dynamics of seasonal changes in humus.

Seasonal Changes in the Nitrogen Content of Soils Under Investigation

The seasonal dynamics of nitrogenous substances in the soils under investigation during the growing period are only broadly comparable to the changes in humus content. These soils may also be subdivided into three groups with respect to total nitrogen content (Table 4).

The first group includes Plot Nos. 4, 5, 7 whose soil contents increased content of nitrogen as well as of humus (0.4%-0.5% N in the 0 cm layer). The second consists of the plots (Plot No. 6) between the wooded tracts with a nitrogen content of 0.38%-0.44%. The third consists of the other plots (Nos. 1, 2, 3, 8, and 9) with a nitrogen content of 0.38%-0.44%.

The nitrogenous substances of shallow chernozems are less dynamic than the carboniferous compounds. The maximum deviations in the direction of a decrease in nitrogen content were noted on September 16 and amounted to 10% (Plot No. 7, 10-20 cm layer); the maximum deviations in the direction of an increase were noted on July 15 and amounted to +22.8% (Plot No. 6, 20-30 cm layer).

It is worth noting that during the growing period none of the plots exhibited the sharp increases in nitrogen content observed by some investigators (1, 2, 5, 17). Even in the 10 cm layer, where the biochemical transformations of matter proceed most vigorously, changes in total nitrogen content were relatively

slight. For example, if the nitrogen content of the soil on May 17 is taken as 100%, it will have the following percentages in the samples obtained at the other times (Table 5).

There was a slight increase in nitrogen in the soil under oak, ash, and Siberian acacia (Plot No. 1) during the first half of the summer, but from August 16 a decrease to the original level (0.33%) occurred. Seasonal changes were almost totally lacking both under dense (Plot No. 8) and under thinned (Plot No. 9) plantings. In the soil with increased humus (Plot No. 5), the amount of nitrogen decreased 16% from its original level by fall, or 0.08% of absolutely dry substance.

The greatest changes between maximum and minimum content of nitrogen in the 30 cm layer during the observation period were noted in June on Plot No. 2 under oak-ash plantation (0.07%), the smallest (0.02% N) on Plot No. 1 (Fig. 2). However, the slight changes in relative nitrogen content of this layer in terms of nitrogen content per hectare are important, as shown by the data in Table 6.

The deviations between maximum and minimum and between initial (May 17) and minimum nitrogen content are equal (1830 kg/ha) only on one Plot (No. 5) because the highest content in the soil of this plot occurred in the spring (May 17), gradually diminishing with time.

Seasonal changes in nitrogen content of the soil under oak plantation (Plot No. 3) are similar, as is evident from a comparison of the changes expressed in relative values (Table 7).

Most of the soils investigated have a higher nitrogen content early in the summer, except the soil under (dense) oak (Plot No. 8) in which the maximum content of nitrogenous substances coincides with the end of the growth period (September 16).

The seasonal changes noted in total nitrogen content undoubtedly depend on a variety of factors: composition, age, density, tree-shrub vegetation and herbage, qualitative composition of soil humus, and weather conditions.

The changes in seasonal dynamics of nitrogenous substances from their initial content (May 17) generally do not exceed the content of readily hydrolyzable forms of nitrogen. Only in the soil of the two plots richest in humus (Nos. 5 and 7) do the changes exceed the quantity of readily hydrolyzable nitrogenous compounds, which, in this case, is relatively small.

Thus, the content of readily hydrolyzable nitrogen in the soil of the first three plots (Nos. 1, 2, and 3) averages about 11% and only about 7% of the total nitrogen content on the plots with increased humus (Nos. 4, 5, and 7).

The ratios of the difference between maximum and minimum nitrogen content of the soil during the growing period (a), on one hand, and the content of readily hydrolyzable nitrogen compounds for the same time (b), on the other, range from 0.5-2.1, as the data indicate.

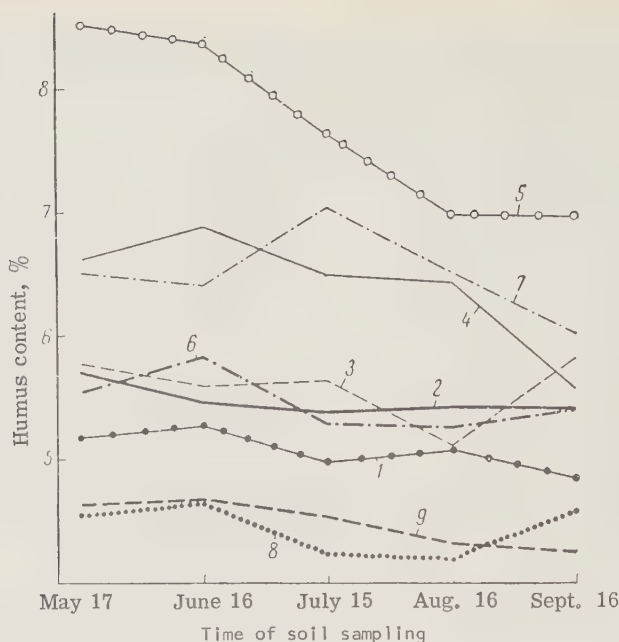


Fig. 1. - Dynamics of humus in the 0-30 cm layer of shallow chernozem under forest stands and in the area in between (in %)

1 - soil under 19-year old oak-maple and acacia plantations; 2 - the same, acacia cut; 3 - the same and acacia cut; 4 - under 52-year old oak-ash-elm plantations; 5 - the same, selectively cut; 6 - in between area under winter wheat; 7 - under 52-year old oak-ash-elm plantation; 8 - under 25-year old oak (dense) plantation; 9 - under 25-year old oak (thinned) plantation

Soil of Plots a:b

No. 1	0.5
No. 2	2.0
No. 3	1.1
No. 4	1.9
No. 5	1.9

Soil of Plots a:b

No. 6	2.1
No. 7	2.0
No. 8	1.0
No. 9	0.8

These data show that the interval of changes in seasonal dynamics of the total nitrogen content of shallow chernozems under forest plantations does not exceed twice the quantity of the readily hydrolyzable compounds of this element.

Conclusions

1. Investigations of seasonal changes of humus and nitrogen in forested, shallow chernozems of the dry steppe have shown that the major changes take place in the 10 cm layer of these soils. Any decrease or increase is due both to decay and consumption or new formation and to mechanical redistribution of these substances caused by the activity of soil animals.

2. Seasonal changes in the humus content of the top 30 cm layer of forested and non-forested plots are slight and virtually match the content of readily hydrolyzable humus substances. Maximum losses of humus during the growing period, ranging from - 18.8% to - 2.4% of its average content, were noted only on the fifth plot (10.22%), which is relatively rich in humus and under a 52-year old plantation of oak, ash, and elm. Humus losses in subhorizon A_1 of this tract amounted to 27.5%, the result of extensive moisture and warming of the top layer of the humus-accumulative horizon as a result of thinning the stand.

3. Nitrogenous compounds in the shallow chernozems were less mobile than humus, judging by the lack of any sharp changes in content during the growing period. Even in the uppermost layers of soil in direct contact with the forest litter, where the biochemical processes are more rapid than elsewhere, seasonal changes in nitrogen content proved to be relatively slight, not more than double the amount of readily hydrolyzable forms of nitrogen. The maximum changes in the seasonal dynamics of soil nitrogen on some plots did not exceed one-seventh of the total or one-fifth

HUMUS AND NITROGEN CONTENT

Table 4

Dynamics of content of total and readily hydrolyzable nitrogen^a under forest plantations during the 1955 growing season

Plot No.	Depth, cm	Sampling time for analysis										
		May 17			June 16	July 15			Aug. 16	Sept. 16		
		a	b	c		a	b	c		a	b	c
1	0-10	0,34	0,043	12,6	0,40	0,40	0,044	11,0	0,33	0,33	0,041	12,4
	10-20	0,32	0,034	10,6	0,32	0,35	0,038	10,5	0,32	0,31	0,029	9,4
	20-30	0,30	0,037	12,3	0,27	0,26	0,038	14,6	0,34	0,31	0,031	10,0
2	0-10	0,38	0,044	11,6	0,43	0,35	0,033	9,4	0,42	0,39	0,038	9,7
	10-20	0,36	0,030	8,3	0,41	0,36	0,036	10,0	0,33	0,34	0,028	8,2
	20-30	0,32	0,034	10,6	0,39	0,30	0,037	8,1	0,31	0,30	0,034	11,3
3	0-10	0,36	0,058	16,1	0,38	0,38	0,047	12,4	0,31	0,35	0,044	12,6
	10-20	0,37	0,043	11,6	0,32	0,34	0,042	12,3	0,30	0,33	0,033	10,0
	20-30	0,29	0,042	14,5	0,31	0,28	0,038	13,6	0,27	0,29	0,037	12,7
4	0-10	0,56	Not det'd.		0,61	0,53	0,039	7,3	0,55	0,49	0,019	3,8
	10-20	0,40	0,029	7,2	0,46	0,43	0,033	7,7	0,44	0,46	0,018	3,9
	20-30	0,40	0,018	4,5	0,40	0,37	0,024	6,5	0,43	0,36	0,026	7,2
5	0-10	0,57	0,037	6,5	0,56	0,49	0,033	6,7	0,49	0,49	0,026	5,3
	10-20	0,49	0,037	7,5	0,48	0,47	0,032	5,8	0,44	0,49	0,029	5,0
	20-30	0,45	0,027	6,0	0,41	0,49	0,033	6,7	0,40	0,44	0,032	7,3
6	0-10	0,43	0,021	4,9	0,41	0,44	0,027	6,1	0,38	0,41	0,034	8,2
	10-20	0,38	0,034	8,9	0,44	0,44	0,026	5,9	0,39	0,41	0,026	6,3
	20-30	0,35	0,031	8,9	0,42	0,43	0,031	7,2	0,36	0,41	0,026	6,3
7	0-10	0,50	0,027	5,4	0,58	0,55	0,048	8,7	0,50	0,47	0,038	8,1
	10-20	0,46	0,025	5,4	0,43	0,50	0,031	6,2	0,48	0,39	0,043	9,9
	20-30	0,40	0,031	7,7	0,40	0,40	0,031	7,5	0,37	0,38	0,038	10,0
8	0-10	0,36	0,029	8,1	0,36	0,35	0,029	8,3	0,34	0,35	0,030	8,6
	10-20	0,29	0,032	11,0	0,27	0,31	0,033	10,7	0,28	0,32	0,032	10,0
	20-30	0,27	0,026	10,8	0,28	0,30	0,029	9,7	0,28	0,31	0,020	6,4
9	0-10	0,38	0,046	12,1	0,36	0,40	0,034	8,5	0,39	0,36	0,041	11,4
	10-20	0,35	0,031	8,9	0,36	0,37	0,035	9,4	0,35	0,36	0,032	8,9
	20-30	0,32	0,030	8,3	0,28	0,32	0,037	11,5	0,33	0,28	0,028	10,0

^aDetermination of total and readily hydrolyzable N was made by Kjeldahl's method; a — N content as a % of dry soil; b — content of readily hydrolyzable forms of N as a % of dry soil; c — content of readily hydrolyzable forms of N as a % of total nitrogen content.

Note: Comma represents decimal point.

Table 5

Seasonal changes in the nitrogen content of the 0-10 cm layer of shallow chernozem under forest plantations

Time of sampling	Plot no.								
	1	2	3	4	5	6	7	8	9
June 16	117,6	113,2	105,6	108,9	98,2	95,5	116,0	100,0	94,7
July 15	117,6	92,1	105,6	94,6	86,0	102,3	110,0	97,2	105,2
Aug. 16	97,9	110,5	86,1	98,2	86,0	88,4	100,0	94,4	102,6
Sept. 16	97,9	102,3	97,2	87,5	86,0	95,4	94,0	97,2	94,7

Note: Comma represents decimal point.

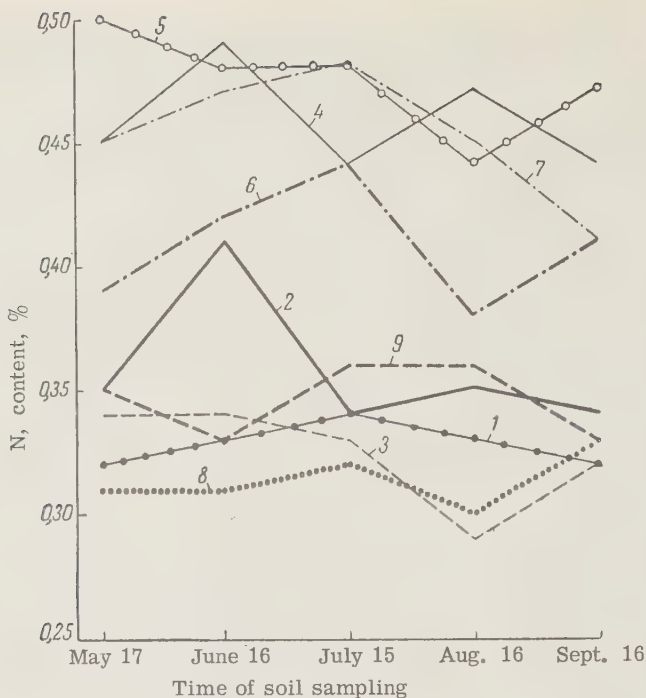


Fig. 2. - Dynamics of nitrogen content in the 0-30 cm layer of the investigated soils under forest plantations and in the area in between. Symbols the same as in Fig. 1.

Table 6

Seasonal changes in the nitrogen content of shallow chernozem under forest plantations

Plot No.	Changes in the nitrogen content of the 0-30 cm layer during the growing season			
	Between maximum and minimum content		Between initial (May 17) and minimum content	
	as a % of dry soil	kg/ha	as a % of dry soil	kg/ha
1	0,02	630	0,0	0,0
2	0,07	2205	0,01	315
3	0,05	1775	0,04	1420
4	0,05	1525	0,01	305
5	0,06	1830	0,06	1830
6	0,06	2136	0,01	356
7	0,07	2135	0,04	1220
8	0,03	945	0,01	315
9	0,03	945	0,02	630

Note: Comma represents decimal point.

in isolated cases.

Received June 2, 1959

BIBLIOGRAPHY

1. ABRAMOVA, M. M. 1947. Seasonal changes

Table 7

Relative changes in the nitrogen content of soil under a 19-year old oak plantation

Plot No.	Time of soil sampling				
	May 17	June 16	July 15	Aug. 16	Sept. 16
3	100	100	98	87	99
5	100	99	99	88	94

Note: Comma represents decimal point.

of certain chemical properties of forest podzolic soil. Tr. Pochv. in-ta im. V. V. Dokuchayeva Akad. Nauk SSSR, Vol. 25.

- VINOKUROV, M. A., and A. N. TYURMENKO. 1958. Materials on the biological cycle of nitrogen and phosphorus in forests. Pochvovedeniye, No. 7.
- GILYAROV, M. S. 1949. Role of soil organisms in formation of the humus layer of soils. Uspekhi sovrem. Biol. No. 6.
- GLINKA, K. D. 1932. Soil science, Moscow-Leningrad.

HUMUS AND NITROGEN CONTENT

5. ZONN, S. V., and A. K. ALESHINA. 1951. Dynamics and nature of action of oak forests on soil. Tr. In-ta lesa Akad. Nauk SSSR, Vol. 7.
6. ZONN, S. V. 1954. Effect of forest plantations on water-soluble compounds of chernozems. *Ibid.*, Vol. 15.
7. ZRAZHEVSKIY, A. I. 1957. Earthworms as a factor in the fertility of forest soils. Kiyev.
8. KRAVKOV, S. P. 1908. Materials for the study of the processes of decomposition of plant residues in soil. St. Petersburg.
9. KRAVKOV, S. P. 1909. Indications of the interaction of decomposition products of organic residues with the constituent elements of soil. Zh. Op. agronomii, Book 1, Vol. 10.
10. KRAVKOV, S. P. 1929. Dynamics of soil processes. Latest developments and outlook in agronomy. Izd. gos. in-ta opyt. agronom., Leningrad.
11. KUZNETSOV, S. I. 1937. Effect of the total readily hydrolyzable nitrogen in clay on the general nature of reduction processes. Mikrobiologiya, Vol. 6.
12. KUZNETSOV, S. I., T. A. SPERANSKAYA, and V. D. KONSHIN. 1939. Composition of organic matter in the clay deposits of different lakes. Tr. Limnologicheskoy st. v. Kosina, Vol. 22.
13. MINA, V. N. 1959. Some problems connected with the study of fertility of forest soils. Pochvovedeniye, No. 6.
14. REMEZOV, N. P. 1959. A method of studying the biological cycle of elements in a forest. *Ibid.* No. 1.
15. SMIRNOVA, K. M., and B. N. GROMASHEVA. 1955. Dynamics of chemical properties of soil under green moss coniferous forests. *Ibid.* No. 6.
16. SOKOLOV, D. F. 1954. Composition of organic matter in oak forest soils. Tr. In-ta lesa Akad. Nauk SSSR, Vol. 23.
17. TYULIN, A. F. 1954. A method of studying the exchange of mineral substances between plant and soil in a forest. *Ibid.*
18. TYULIN, A. F., and K. G. SHCHERBINA. 1954. Biological cycle of nitrogen and phosphorus between plant and soil in broad-leaf forests in the southern part of the forest steppe during the growing season. Dokl. Akad. Nauk SSSR, Vol. 97, No. 1.
19. TYULIN, A. F., and K. G. SHCHERBINA. 1955. Mineral nutrition of oak in the Tellermanov Experimental Forest. Tr. In-ta lesa, Vol. 24.
20. TYURIN, I. V. 1937. Organic matter in soil. Sel'khozgiz, Leningrad.
21. TYURIN, I. V., and M. M. KONONOVA. 1934. A new method of determining the nitrogen requirement of soils. Tr. Pochv. in-ta im. V. V. Dokuchayeva Akad. Nauk SSSR, Vol. 10, No. 4.
22. TYURIN, I. V., and M. M. KONONOVA. 1935. Methods of determining the nitrogen requirement of soils. *Ibid.*, Vol. 12.
23. TYURIN, I. V. 1951. A method of analysis for a comparative study of composition of soil humus. *Ibid.*, Vol. 38.
24. SHUMAKOV, V. S. 1941. Dynamics of the decomposition of plant residues and interaction of their decomposition products with forest soil. Tr. VNILKh, Vol. 1, No. 24.
25. FEHER, D. 1931. Die restlichen Veränderungen des Humusgehaltes des Waldbodens. Silva, Vol. 19. Munich.

SOIL FORMATION IN THE LOW MOUNTAIN REGION OF THE NORTH ALTAY¹

YE. G. CHAGINA, Altay Agricultural Institute

Soils of the North and Northwest Altay low mountain region have long been of interest to soil scientists because of their high humus content, structural quality, and other valuable agronomical properties (1, 2, 6, 11). Rozanov (14) attributes the development of these soils to certain biological and climatic conditions characteristic of Southern Altay province. Karmanov (4) includes the chernozems developed here with the subgroup of typical soils.

The relief of the region is very rugged. The difference in altitudes between the bottom of a valley and peak of a mountain may be as much as 300 m. The northern slopes are occupied by aspen-fir forests with umbellate, coarse grasses and ferns. The southern slopes have a meadow-steppe vegetation consisting 40%-50% of grasses: meadow grass, fescue, orchard grass, wheatgrass, couch and meadow motley grass. Until 50 years ago the northern slopes were solidly covered with forests. They are now largely gone owing to the growth of the city of Gorno-Altaysk nearby.

The soils of the region are unusual. The mountain relief is responsible for the development of several soil varieties not far apart (80-100 m) on the slopes. For example, the southern slopes have soils ranging from shallow leached chernozem on the peaks to thick meadow soils in the valleys through podzolized chernozem, dark-gray podzolized and meadow-dark-gray podzolized soils on the slopes. Under the forests on the northern slopes are thick meadow and meadow-dark-gray podzolized chernozem soils. One may encounter along the ridges gravelly soils with gravel deposited at various depths (these soils were not studied).

All the soils, both those under meadow-steppe vegetation and those under aspen-fir taiga, are characterized by high humus content with a predominance of humic acids and weak development of podzolization. At the same time in neighboring Salaira light-gray, deeply and strongly podzolized soils with light-colored horizon A_1 and distinct horizon A_2 are formed under aspen-fir taiga.

The soils in this region adjoin the chernozem-

forest soils of the larch forests investigated by Gradoboyev (3). However, the latter are not podzolized at all and they have low hydrolytic acidity, which distinguishes them from the soils studied by us.

The rugged North Altay low mountain region is not suitable for raising grain crops. However, the climate and soil are very good for West Siberian horticulture. The mean annual temperature is $+1.4^{\circ}\text{C}$, the annual rainfall is about 700 mm with a maximum during the summer. The amount of snow is sufficient so that in some winters the soil doesn't freeze even during the most severe freezing.

Our semi-field investigations were made in the orchard of the Gorno-Altaysk Field Station where the soils have been under cultivation for 25 years.² Simultaneous studies at the Kayas landmark and on "Fir" mountain both under forests and on open grazing land showed that the soil of the station was typical of the entire region.

The preceding soils have the following morphological characteristics (Table 1).

The thickness of the humus horizon down the slope increases from 30-40 cm in the chernozem, where erosion is possible, to 80-120 cm in the meadow soils. Carbonates in the leached chernozem are produced in the form of pseudomycelium at a depth of 55-60 cm; calcareous inclusions are frequent between 120-130 cm. Calcareous inclusions in the dark-gray soil are full of dark-cinnamon-brown streaks and are easily fractured along these streaks. In the meadow-dark-gray and meadow soils there is no effervescence to a depth of three meters. Siliceous powder starts to appear in the podzolized chernozem. It is more abundant in the soils further down the slope. The illuvial horizon begins in the podzolized chernozem in the form of dark-cinnamon-brown compact nutty crusts on the edges of structural units. In the illuvial horizon of the dark-gray podzolized soil streaks can be discerned along the cracks and edges of prismoidal structural units, dark brown when wet and almost black when dry. In the lower part of the profile the intrusions are found deep, sometimes

¹ Done under the direction of Prof. N. V. Orlovskiy.

² T. P. Barabash, director of the station, was very helpful in the field work.

SOILS OF NORTH ALTAY

Table 1

Changes in the morphological characteristics of soils along the slope from mountain peak to valley bottom

Soil	Humus horizon	Thickness, cm	Structure of humus horizon	Depth to the carbonates, cm	Presence of SiO ₂ sprinkling	Water table
Chernozem, leached, shallow	A + B	29—40	Granular	55—70	None	None
Chernozem, podzolized, shallow and medium thick	A + B	35—50	"	70—90	Weak in horizon B	"
Dark-gray podzolized, medium thick, more rarely shallow	A ₁ + A ₁ A ₂	30—60	Roe-granular	100—120	Distinct horizons A ₁ A ₂ and A ₂ B ₁	"
Meadow-dark-gray podzolized soil	A ₁ + A ₁ A ₂	60—70	Roe	About 3 m none	Abundant in horizons A ₁ A ₂ and A ₂ B ₁	Lower horizons wet
Meadow, thick soil	A + B	80—120	"	None	None, weak gleying	At 50-150 cm, depending on the precipitation

30-40 cm, in the carbonate horizon. They do not effervesce on the colored side, but there is vigorous effervescence under the crust to a thickness of 1 mm. Dark cinnamon-brown intrusions are not present in the meadow-dark-gray and meadow soils. Instead we find in the illuvial horizon dirty gray, scarcely perceptible diffuse bluish spots indicative of the beginning of gleying. Water table is frequently observed in meadow soil to a depth of 50-60 cm after heavy precipitation, but at a depth of 150 cm or more during arid periods.

The leached and podzolized chernozems have clearly pronounced granular structure in the humus horizon. The structure is not so distinct in the dark-gray soil (roe finely-granular); it is less distinct in the meadow-dark-gray and meadow soils. These differences are attributable to the texture. For example, the uppermost chernozem horizon contains elevated elements of the relief is coarse sandy-clayey clay containing 36%-40% particles 0.001 mm in diameter. The amount of clay in the same horizon of the meadow-dark-gray and meadow soils decreases to 26%-31% and the heavy silt fraction becomes predominant (35%-40% instead of 26%-30% in the chernozem). In meadow soils as in the dark-gray soils there is extensive movement of clay particles into the lower horizons, the content of particle diameters 0.001 mm in the illuvial horizons amounting to 36%-46% (Table 3).

The formation of a stable granular structure in the soils of all elements of the relief is also due to the vigorous activity of the many earthworms present, as observed by Sokolov (15) in similar soils of Southwest Altay. Earthworms are particularly active in soils with high humus content (chernozems). The structural characteristics of the chernozem-meadow soil, which has high water stability, were thoroughly studied by Ostroumov (11) in the Mayma River

valley, having similar conditions.

The morphological characteristics and data of chemical analyses show that the sod process is developed in all the soils along the slope and is associated with intensive accumulation of humus and exchangeable calcium (Tables 2 and 3). It will be noted that the humus content and thickness of the humus horizon increases the further one goes down the slope. At the same time the process of podzolization is intensified toward the bottom of the slope.

The humus content increases steadily from the leached chernozems to the meadow soils. It varies in A horizon of the former from 6.0%-9.5%, amounting to 13%-14% or even 16% in the meadow soils. The distribution of humus through the profile tends to become more even in the more moist places.

Total humus content in the soils from other places (Kayas landmark, "Fir" mountain) showed that the high humus content in the soils of the field station is not the result of cultivation, but is characteristic of the entire region under investigation.

The qualitative composition of humus was determined from three soil profiles taken from the portion of the slope facing south-southwest. Three samples were analyzed from the illuvial B₂ horizon of the dark-gray soil: 1 - a sample from a depth of 70-80 cm with no dark-cinnamon-brown intrusions; 2 - from a depth of 85-95 cm with intrusions; 3 - crusts from this horizon, which were carefully scraped off with a knife when the samples were obtained in the field. The humus composition was analyzed by Tyurin's method (17, 5).

The data in Table 2 show that in the uppermost horizons of all the soils investigated the humic

Table 2

Content and composition of humus in soils of the North Altay low mountain region (Analysis according to method of I. V. Tyurin)

Horizon	Depth, cm	Carbon of original soil, %	Humus as a % (CxI, 724)	Carbon in organic matter in composition of humus as a % of total carbon of the original soil											C of humic acids		C of fulvic acids	
				Extracted after de- calcification of soil with 0.05 n HCl	Extracted after di- rect processing with 0.1 n NaOH	Humic acids					Fulvic acids					Nonhydrolyzable residue (humins)	14	15
						Total	Group I including Tied up with Ca, column 6-7	Group II	Total	Group I	Group II	Total						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15				
Chernozem, leached, shallow																		
A	0-8	5.51	9.50	5.8	13.6	31.0	7.1	23.9	5.4	36.4	21.4	2.6	24.0	23.6	1.51			
B	20-28	2.15	3.71	8.8	8.8	24.7	1.9	22.8	3.9	28.6	24.2	2.1	26.3	23.7	1.09			
BC	32-40	1.45	1.88	9.6	7.8	15.2	0.9	14.3	0.8	16.0	26.9	0.8	27.7	31.3	0.58			
C	50-57	0.69	1.19	10.1	4.3	8.7	1.0	7.7	1.0	9.7	26.1	1.2	27.3	38.7	0.36			
Dark-gray podzolized soil																		
A	0-10	5.49	9.46	8.7	20.0	36.4	11.7	24.7	5.0	41.4	18.6	2.2	20.8	22.8	2.00			
A ₁ A ₂	25-34	2.31	3.98	4.8	13.9	36.8	3.9	32.9	5.4	42.2	24.7	1.9	26.6	21.2	1.59			
A ₃ B ₁	35-45	1.35	2.33	8.9	12.6	27.4	3.0	24.4	3.3	30.7	24.5	1.9	26.4	22.2	1.16			
B ₁	50-60	0.63	1.08	12.7	8.0	11.1	1.6	9.5	0.8	11.9	28.6	0.7	29.3	33.3	0.41			
B ₂	70-80	0.50	0.86	10.0	8.0	8.0	1.2	6.8	0.7	8.7	32.0	0.9	32.9	33.5	0.26			
B ₃	85-95	0.44	0.75	13.6	4.6	6.8	0.9	5.9	0.8	7.6	27.2	1.0	28.2	36.4	0.27			
Crusts		0.66	1.14	22.7	27.7	9.7	0.6	9.1	0.6	10.3	27.3	0.7	28.0	30.3	0.37			
Meadow-dark-gray podzolized soil																		
A	0-10	6.70	11.45	8.4	37.9	43.7	25.8	17.9	5.5	49.2	15.2	1.8	17.0	21.6	2.89			
A	21-28	4.63	7.98	5.0	46.9	54.0	30.9	23.1	5.0	59.0	14.0	1.1	15.1	17.9	3.90			
A ₁ A ₂	40-50	2.49	4.29	6.0	41.0	52.0	25.3	26.7	5.2	56.2	16.1	1.5	17.6	21.3	3.20			
B ₁	60-70	1.24	2.14	6.5	29.8	47.6	10.5	37.1	1.6	49.2	17.8	0.8	18.6	25.0	2.65			
B ₃	85-95	0.44	0.75	12.1	12.6	16.6	0.0	16.6	0.2	16.8	25.0	0.5	25.5	40.9	0.66			

Note: Comma represents decimal point.

SOILS OF NORTH ALTAY

Table 3

Content of exchangeable bases and degree of soil saturation

Horizon	Depth, cm	Exchangeable bases			Hydro-lytic	Exchange	Degree of base saturation, %	Ca + Mg per 100 g of humus, meq	Particle diameters 0.001 mm %
		Ca	Mg	Total	Acidity				
		Meq per 100 g of soil							
Chernozem, leached, shallow									
A	0—8	36,9	6,9	43,8	5,0	Not det'd.	90	265	36,5
B	20—28	32,5	3,6	36,1	3,3	"	92	270	44,5
BC	32—40	29,8	1,4	31,2	3,0	"	96	238	43,9
Dark-gray podzolized soil									
A	0—10	34,9	2,6	37,4	10,7	Not det'd.	78	212	36,5
A ₁ A ₂	25—34	28,2	2,6	30,8	7,3	"	81	174	41,6
A ₂ B ₁	35—45	25,2	2,5	27,7	6,6	"	81	93	43,1
B ₁	50—60	24,6	2,3	26,9	4,3	"	86	14	46,4
B ₂	70—80	27,3	2,3	29,6	3,6	"	89	—	44,1
Meadow-dark-gray podzolized soil									
A	0—10	32,7	4,3	37,0	11,1	0,4	77	236	26,6
A	21—28	25,8	3,0	28,8	13,4	0,3	68	199	28,3
A ₁ A ₂	40—50	20,0	2,8	22,8	11,1	0,4	67	102	33,6
B ₁	60—70	16,1	2,4	18,5	6,4	0,6	74	—25	32,4
B ₂	85—95	19,3	3,5	22,8	3,7	0,3	86	—	36,8
B ₂	110—120	23,0	4,9	27,9	3,0	0,6	90	—	44,6
B ₂	140—150	24,0	6,3	30,3	Not det'd.		—	—	47,1
B ₂	200—215	24,1	6,6	30,7	"		—	—	48,9
C	283—293	22,2	5,6	27,9	"		—	—	46,3
Meadow, thick soil									
A	0—10	42,8	5,0	47,8	9,4	Not det'd.	84	—	29,7
A	24—32	39,5	3,2	42,7	12,4	"	77	—	31,3
A	50—60	34,0	4,1	38,0	10,5	"	78	—	37,4
B	100—110	24,2	2,4	26,6	5,8	"	82	—	40,1
BC	140—150	22,2	4,3	26,5	3,7	"	88	—	39,1

Note: 1. Exchangeable Ca was determined using Gedroyts' method with Lobanov and Biryukov's modification (9), the total of Ca+Mg from the same extract by the trilonometric method. 2. Hydrolytic and exchange acidity according to Kappen with a coefficient of 1.75.

Note: Comma represents decimal point.

ds predominate over the fulvic acids, the ratio of humic acids to fulvic acids widening with larger amounts of humus. However, as pointed out previously, at the same time signs of podzolization become increasingly prominent. For example, in the upper horizons of the leached chernozem, the ratio of humic acids to fulvic acids is 1.51 and 1.09, whereas in the meadow-dark-gray podzolized soil it is 2.89 and 2.0. This ratio decreases with depth in all the soils studied (less than one) as a result of the increased content of humic acids in the humus and a marked increase in fulvic acid content.

The increase with depth of the amount of hydrolyzable residue, especially significant in those horizons where the ratio of humic acids to fulvic acids is less than one, is noteworthy.

Humus substances extracted after direct leaching of the soil with 0.1 n NaOH are represented, according to I. V. Tyurin, as a com-

plex of weakly dehydrated brown humic (ulmin type) acids with fulvic acids. The contents of this type, in the humus composition of the soils investigated, grow as the degree of podzolization increases (Table 2, column 5). This increase in the upper horizons is caused chiefly by the greater content of free or bound (with mobile forms of R₂O₃) humic acids and, in the lower horizons, of fulvic acids (cf. Table 2, columns 5 and 7). Thus, increasing podzolization down the slope is accompanied by mounting degree of mobility of humus substances, which is confirmed by the increased amount of organic substances (extracted after decalcification of the soil with 0.05 n HCl (Table 2, column 4) in the humus, especially in the lower horizons of the profile. The content of the latter is unusually large in crusts from horizon B₂ (22.7%). Humic acids in the soils investigated are represented chiefly by a group bound with Ca (Table 2, column 8). With increasing degree of podzolization the content of humic acids bound with Ca

changes as follows. In the leached chernozem the maximum content of this group occurs in A horizon, in the dark-gray soil this maximum shifts to A₁A₂ horizon, while in the meadow-dark-gray soil it is in B₁ horizon (at a depth of 60-70 cm). According to Ponomareva (13), "acid" Ca humates in forest-steppe soils may move down deep into the profile with downward flow of water. This is suggested by the materials of Myasnikova (10), who attributes the presence of humic acids bound with Ca in the lower horizons to their movement there in the form of ulmic acids (extracted after directly treating the soil with alkali) and subsequent aging with conversion into humic acids.

The greater mobility of Ca humates in the more podzolized soils of the series under study is due to decreased saturation of the humus of these soils with exchangeable bases, as found by calculation. The content of exchangeable bases (Ca+Mg) per 100 g of humus³ is calculated from Ponomareva's formula (12),³ which we made more accurate

$$X = a - \frac{(b-d) \cdot c}{d} \cdot 100,$$

where X is the number of meq of Ca+Mg per 100 g of humus; a is the number of meq of Ca+Mg per g of soil; b is the clay content as a %; d is the % of humus; c is the number of meq of Ca+Mg per 100 g of clay taken as 62.5 meq as calculated in the nonhumus horizons. The results of the calculations according to this formula showed that the "humus capacity" differs from soil to soil (Table 3). It is the greatest in the chernozem, amounting to 265-270 meq/100 g of humus and remains virtually constant through the profile. In the 0-10 cm layer of the

dark-gray and meadow-dark-gray soils the humus capacity drops to 212 and 236 meq, decreasing rapidly with depth; at 50-70 cm the humus, according to this calculation, is completely unsaturated. If the formula is correct,⁴ we may assume that the presence of unsaturated forms of humus in the lower horizons of the soils under study is due to the above-mentioned movement of "acid" Ca humates with subsequent combining chiefly with sesquioxides.

The soils of the series being studied are characterized in the upper horizons by increased hydrolytic acidity decreasing with depth through the profile and very low exchangeable acidity (Table 3). The degree of hydrolytic acidity increases down the slope from the leached chernozem to the meadow-dark-gray and meadow soils.

Increasing hydrolytic acidity down the slope is due to the greater moisture content of these soils resulting in faster leaching of bases from the decomposing organic residues. The organic acids thus produced remain unsaturated (7).

The distribution curve of hydrolytic acidity through the profile is shown in Figure 1. The curve for the humus content of substances extracted after directly treating the soil with 0.1 n NaOH is similar. We may assume from the indicated intensity of changes in hydrolytic acidity through the profile and in content of free and bound (with mobile forms of R₂O₃) humic and fulvic acids in humus that it is the acids extracted after directly treating the soil with alkali that are responsible for the hydrolytic acidity present in these soils. Khtryan (18) expressed a similar view in connection with the mountain-meadow soils of the Caucasus.

The amount of exchangeable bases in the soils under study is relatively small considering that

³ The improvement in accuracy consists in the addition of the curves, wherein the percent humus in the total clay content is calculated, since the clay fraction contains humus.

⁴ The formula presupposes the constancy of exchange capacity of clay in the mineral portion of the entire profile, which cannot always take place.

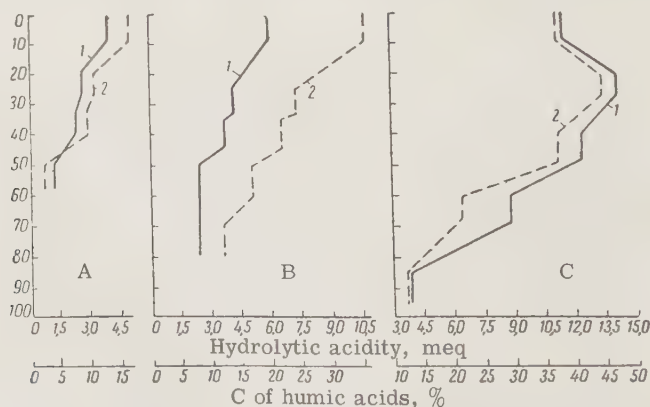


Fig. 1. - Changes along the soil profile in hydrolytic acidity and humus substances extracted after directly treating the soil with 0.1 n NaOH

A - leached chernozem; B - dark-gray podzolized soil; C - meadow-dark-gray podzolized soil. 1 - C of humic acids; 2 - hydrolytic acidity.

are high in humus content. In meadow-
 chernozem soils with similar texture the ex-
 change capacity amounts to 55-60 meq or more.
 It will be noted that with more humus in the
 meadow-dark-gray soil the content of ex-
 changeable bases in A horizon is lower than in
 the chernozem (37.0 meq as against 43.8 meq).
 Depletion of bases in the eluvial horizon and en-
 richment of the illuvial horizon with them is a
 clearly defined process. This phenomenon is
 caused by removal of the clay fraction and the
 overall low humus capacity of the meadow-dark-
 gray soil, as mentioned previously. The degree of
 base saturation decreases as podzolization in-
 creases. This process is promoted by the
 constant and periodically observable lateral
 seepage, as experimentally demonstrated.

Soils on the low elements of the relief are
 more podzolized despite their higher moisture
 content. Podzolization is reflected in the mor-
 phology, more pronounced removal of clay par-
 ticles, decrease in content of exchangeable
 bases with depth, degree of base saturation, but
 also in an increased hydrolytic acidity. At the
 same time the more podzolized soils have a
 higher humus content. Despite the great ac-
 cumulation of humus, there is a higher content
 of humic acids in its composition, a confirma-
 tion of the general pattern (Tyurin, 197).

We may assume from the fact that fulvic
 acids are more soluble than humic acids (5)
 that despite the higher moisture content of soils
 on the slope the fulvic acids are leached from
 the upper horizons, causing them to become
 podzolized, and accumulate in the illuvial hori-
 zon (cf. the results of analyzing crusts from
 the horizon). The humic acids being less
 soluble remain in the upper part of the profile.
 The humic acids are more mobile in the
 meadow-dark-gray soil in view of the large
 amounts of moisture present. Thus, although
 there is a contradiction between the accumula-
 tion and eluvial processes, soil formation in the
 soil series being investigated takes place despite
 intensified meadow formation down the slope.

Materials in our possession on other objects
 confirm the pattern described.

The explanation of the considerable humus
 accumulation in all the soils under study, es-
 pecially those without trees, is evidently to be
 sought in the history of soil formation in this
 region. After studying Gornyy Altay vegetation,
 Vinova (8) came to the conclusion that "the
 natural course of transformation of vegetation
 now due to increased moisture, as manifest-
 ed by the replacement of relatively drought-
 resistant formations with more moisture-loving
 formations: pine forests with fir, larch forests
 with cedar, tundra moss on underbrush and
 fern, etc." In the northern low mountain
 region of Altay forests have clearly encroached
 on meadow steppes, especially along the
 northern slopes. The long growth of forests on
 meadow chernozems has still not resulted in
 substantial change in the direction of pod-
 zolization. The latter occurs only on the middle
 lower portions of slopes as a result of in-
 creased moisture along with lateral seepage.

Conclusions

1. Soils high in humus are very common in
 the low mountain region of the Altay on the
 northern slopes under aspen-fir forests and on
 the southern slopes under meadow-steppe vege-
 tation. These soils constitute the main re-
 sources for the development of commercial
 fruit orchards in the Altay. The following
 properties are characteristic of them:

a) high humus content combined with signs of
 podzolization, more clearly manifested in the
 lower part of the slope. At the same time
 there is an accumulation of humic acids with
 increased mobility as well as movement and ac-
 cumulation of fulvic acids in the lower soil
 horizons, especially in the crusts of intrusions;

b) high hydrolytic acidity despite very low
 exchange acidity apparently as a result of humic
 acids, which are extractable by directly treating
 the soil with 0.1 n NaOH.

2. The phenomenon of high humus accumula-
 tion in the forest soils is explained by the
 hypothesis of a two-phase process of soil forma-
 tion in this region.

Received May 28, 1959

BIBLIOGRAPHY

1. VYDRIN, I. P. and Z. I. ROSTOVTSSEV.
 1899. Materials on an investigation of
 soils in the Altay district. Barnaul.
2. GORSHENIN, K. P. 1955. Soils of Southern
 Siberia. Izd. Akad. Nauk SSSR.
3. GRADOBOYEV, N. D. 1955. Siberian larch
 forest soils. Tr. po lesnomu khoz. No.
 2. ZSF Akad. Nauk SSSR.
4. KARAMANOV, I. I. 1958. Some genetic
 and provincial peculiarities of typical
 Northwest Altay chernozems. Pochvove-
 deniye, No. 3.
5. KONONOVA, M. M. 1951. Soil humus and
 modern tasks in studying it. Moscow-
 Leningrad.
6. KOPOSOV, N. A. 1936. Soils in North-
 eastern Altay (Oyrot). Izd. Akad. Nauk
 SSSR.
7. KRAVKOV, S. P. 1908. Materials on an
 investigation of the decay processes of
 plant residues in soil. St. Petersburg.
8. KUMINOVA, A. V. 1959. Ways in which
 Altay vegetation is formed. In the col-
 lection: Papers and summaries of papers
 read at the scientific conference on
 "Nature and natural resources of Altay
 Krai." Biysk.
9. LOBANOV, N. I. and L. G. BIRYUKOV.
 1957. Determination of Ca and Mg (ad-
 sorbed bases). Pochvovedeniye, No. 4.
10. MYASNIKOVA, A. M. 1956. Accumulation
 and qualitative composition of humus in

- the gray soils of the Les na Vorskle National Forest. Uch. zap. LGU, No. 221, ser. biol. nauk No. 42.
11. OSTROUMOV, B.V. 1956. Description of the chernozem-meadow soils of the Mayma River valley (Gornyy Altay). Pochvovedeniye, No. 6.
 12. PONOMAREVA, V.V. 1955. Role of vegetation in podzol formation. Pochvovedeniye, No. 8.
 13. PONOMAREVA, V.V. 1956. Nature and geographical patterns of podzol formation. Pochvovedeniye, No. 3.
 14. ROZANOV, A.N. 1957. Natural conditions of Altay Kray and development of virgin and long-fallow sands. Izv. Akad. Nauk SSSR. Ser. Biol. No. 4.
 15. SOKOLOVA, A.A. 1956. Significance of earthworms in soil formation. Alma-Ata.
 16. TYURIN, I.V. 1939. Forest-steppe soils. Pochvy SSSR, Vol. 1, Izd. Akad. Nauk SSSR.
 17. TYURIN, I.V. 1951. Studies on organic matter in soil. Tr. Pochv. in-ta, Vol. 1.
 18. KHTRYAN, N.K. 1957. Nature of the acidity of mountain-meadow cinnamon-brown soils on the Pambakskiy mountain range. Byul. in-ta inform. Armyansk. NII Zemledel., No. 2.

DIAGNOSTIC INDICES OF SOD-PODZOLIC SOILS AT VARIOUS LEVELS OF CULTIVATION

I. GRIGOR'YEV, V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR

For 3 years the V. V. Dokuchayev Soil Institute of the USSR Academy of Sciences has been studying large-scale soil mapping methods on a sovkhos in the Smolensk region, in the subzone of sod-podzolic soils.¹

No marked differences could be detected in the structure of the morphological profile of the virgin soils and their cultivated variants (allowed and abandoned lands). Morphological differences are normally only found in the structure of the uppermost section of the profile, where they consist of an increase in the thickness of the A₁ horizon, which is more deeply colored in the cultivated soil (at or above average level of cultivation), and variation in structure in the same horizon. In or below horizon A₂ (or B₁ in sod weakly-podzolic soils) the morphological differences between virgin and cultivated soils become less apparent. It is only in well-cultivated soils (old gardens and orchards) that the morphological structure of the profile loses its initial sod-podzolic form to a considerable depth.

Nevertheless, chemical analyses show that there are very considerable differences in the properties of virgin and cultivated soils of the same species and types. These differences are marked in highly cultivated sod-podzolic soils.

Field and laboratory studies have yielded data from which typical indices for sod-podzolic soils at different levels of cultivation can be established. One of the many classifications of cultivated sod-podzolic soils had to be taken as a basis. Without making a critical review of the many classifications, we should like to draw attention to the work of Blagovidov (3) and Zavalishin (4, 5), in which one of the fundamental aspects of this problem — the degree of the cultivation process — is examined.

Blagovidov defines the nature of cultivated sod-podzolic soil as "... change under agricultural productivity of climatic, botanic,

hydrogeological and other conditions, leading to a basic and controlled change in the biological cycle." Blagovidov ascribes the following features to cultivated soils: "... biologically active soils supplied with humus, saturated with calcium, structured, and enriched with a balanced content of the ash and nitrogen elements of plant nutrition and available moisture are desirable in the agriculture of all zones" (2).

Zavalishin (5) treats the cultivation of sod-podzolic soils as a soil-forming process that is markedly similar to the sodding process. Our "working" classification is based on this point of view. Our experimental material also pointed to the need to group cultivated soil variants in a separate group (subgroup?), genetically closely linked to sod-podzolic soils, but developed by a "cultivation" process similar to soil formation but with its own specific features.

Accepting this concept enables one to define the level of cultivation of sod-podzolic soils from the degree of development of the sodding process, the most fundamental features of which are "... accumulation in the accumulative horizon of humified organic matter that is more or less saturated with bases and sesquioxides and of ash elements that form stable compounds..." (5).

Our study of the morphology and physico-chemical properties of cultivated sod-podzolic soils has led us to distinguish three levels of cultivation: 1) slightly cultivated, 2) moderately cultivated or sod residual-podzolic (Zavalishin's terminology) and 3) well-cultivated or sod cultivated. We shall describe these soil species below.

The cultivated sod-podzolic soils can best be traced by comparing the properties of virgin and slightly cultivated soils and subsequently examining the properties of soils at "higher" stages in the formation of the soil by cultivation.

We shall examine the most typical features of virgin sod-podzolic soils developed on clay loam deposit. The heterogeneity of the soil, largely associated with the local relief, is here revealed most clearly. Sod moderately-podzolic coarse clay loams predominate and sod

The work was directed by Grigor'yev and carried out by workers of the Institute (Shershukova, Kononova, Denisova, Sinitsyna, Stepanov and Smirnova). N. I. Liverovskiy was responsible for the overall scientific direction.

strongly-podzolic and, especially, sod weakly-podzolic soils are much less common.

Sod weakly-podzolic soils are associated with "protruding" forms of (micro- and meso-) relief, where there is good surface runoff.

Sod moderately-podzolic soils are found either on wide flat elevated sectors, on which runoff is impeded or in shallow "semi-closed" depressions.

Sod strongly-podzolic soils are largely associated with small-scale depressions or broad flat hollows and almost invariably show some signs of gleying.

The humus horizon in virgin sod-podzolic soils is rarely thicker than 10-15 cm.

The illuvial (A_2) horizon varies in thickness in the different species. In sod weakly-podzolic soils the A_2 horizon is usually a discontinuous 1-3 cm layer or appears as a A_2B horizon, in which there are only small whitish spots and "pockets" of the podzolic horizon.

We took 3-10 cm as the thickness of the A_2 horizon in sod moderately-podzolic soils. The A_2 horizon is here always continuous and clearly defined and its lower limit is sometimes uneven. When the A_1 horizon is thin the A_2 horizon is thicker than 10 cm. Iron-manganese concretions ("grains" and "beans") are almost invariably found in the A_2 horizon and in the upper part of the A_2B horizon. The A_2B horizon is usually well defined and consists of deeply penetrating whitish tongues with wedges.

Chemical and particle-size analysis data for the three virgin soils are given in Table 1.

The most fundamental features of sod-podzolic virgin soils are:

1. A high relative exchangeable hydrogen content, attaining 28% of the total of exchangeable cations even in sod weakly-podzolic soils.

2. Low pH of a salt extract, varying between 3.8 and 4.2 (rarely above) and high hydrolytic acidity that only declines in the A_2 horizon.

3. In the A_2 (and A_2B) horizons of sod moderately- and strongly-podzolic soils there is a marked decline in: the content of exchangeable bases (1.9-2.6 meq), the adsorption capacity (the total exchangeable $Ca + Mg + H$ of the hydrolytic acidity only reaches 5-6 meq) and the clay content. At the same time in the B_1 horizon the total exchangeable bases and the clay content are clearly maximized.

4. The level of base saturation in the upper 30-50 cm layer rarely exceeds 50%.

5. The content of easily soluble P_2O_5 and exchangeable potassium in virgin sod-podzolic soils is not very large. Since there is a typical sharp decrease in the exchangeable potassium content and hydrolytic acidity in the A_2 horizon of moderately- and strongly-podzolic soils, these indices can be used in diagnosis.

Table 1, also shows no fundamental differ-

ences in the stage between sod moderately- and strongly-podzolic soils and that their separate identification can only be provisional. The thickness of the A_2 horizon is the most reliable and convenient indicator.

Let us examine the data for analyses of sod-podzolic slightly cultivated soils given in Table 2.

Old plowed sod weakly-, moderately- and strongly-podzolic soils were analyzed. The virgin soils dealt with previously were not the direct antecedents of the cultivated soils examined in Table 2, but their situation was similar, within the same geomorphological element and on parent materials of identical texture.

Somewhat different morphological indices were taken for the various species of cultivated sod-podzolic soils than for the virgin soils. Thus, soils in which the A_2 horizon was absent or only present in the form of small isolated lenses and "pockets" were treated as sod weakly-podzolic. The A_2 horizon was well defined (continuous) in sod moderately-podzolic soils and between 2 and 6 (8) cm thick.

Soils classified as strongly-podzolic had an A_2 horizon thicker than 6-8 cm. The analytical data show that even at a stage of slight cultivation, the physicochemical properties of sod-podzolic soils differ markedly from those of their virgin analogues.

1. In slightly cultivated sod-podzolic soils there is a marked decline in both the absolute and relative values for exchangeable hydrogen: hydrogen content does not exceed 3%-6% of the exchangeable cations of weakly-podzolic soils; in moderately- and strongly-podzolic soils hydrogen content is more significant but does not exceed 29% of the total of exchangeable cations.

2. The marked decrease in hydrolytic acidity leads to a perceptible increase in the level of base saturation, which does not fall below 70% in weakly-podzolic soils and is noticeably increased in moderately- and strongly-podzolic soils. The pH of a salt extract is also considerably less acid in the upper horizon.

3. The humus content of the A_1 horizon is considerably reduced (by comparison with virgin soils) as has been shown by Zavalishin (4) and Vazhenin (3).

4. The typical features of the A_2 horizon are retained. The total exchangeable bases, the adsorption capacity and the clay content are all sharply reduced. This shows that slight cultivation suppresses but does not eliminate the process of podzolic formation.

5. There is no difference between slightly cultivated and virgin soils in the content and distribution of easily soluble phosphates and exchangeable potassium. There is a sharp decrease in the amount of exchangeable potassium in the A_2 horizon and a significant (and often marked) increase in the content of easily soluble P_2O_5 (for which there is as yet no satis-

DIAGNOSTIC INDICES OF SOD-PODZOLIC SOILS

Table 1

Chemical analysis data for sod-podzolic coarse clay loam virgin (forest) soils

Profile No.	Soil and location	Horizon	Depth, cm	pH, salt	Humus (Tyurin's method), %	Total nitrogen (Kjeldahl's method), %		Easily soluble P ₂ O ₅ (Kirsanov's method) in mg per 100 g	Exchangeable potassium (Maslova's method)		Hydrolytic acidity (Kappen's method)		Degree of saturation with bases, a %	Exch. ca. by Gedyroy's method			H as a % of total exchangeable cations	Particle diameter	
						In %	In mg per 100 g		In meq	In meq	In meq	In meq		Ca	Mg	H		Clay (<0.001 mm)	Physical clay
126	Sod weakly-podzolic coarse clay loam; spruce forest, 900 m to the s. e. of Kuz'mino.	A ₁	2-7	4, 2	3, 7	0, 19	6, 2	10, 0	6, 0	7, 5	4, 5	38	Not det'd.	0, 5	Not det'd.	10	7, 4	21, 1	
		A ₂ B	18-23	4, 1	0, 9	0, 13	4, 4	7, 5	3, 8	5, 5	4, 5	45	"	1, 9	"	28	13, 1	24, 7	
		B ₁	35-40	4, 0	0, 6	0, 13	2, 2	7, 5	5, 3	6, 5	1, 0	13	"	2, 3	"	27	19, 2	30, 2	
		B ₁	60-65	4, 1	0, 2	Not det'd.	Not det'd.	7, 5	Not det'd.	4, 5	5, 5	55	"	2, 0	"	27	16, 5	26, 0	
		BC	90-95	3, 9	Not det'd.	Not det'd.	Not det'd.	7, 5	"	5, 3	11, 0	67	"	2, 6	"	19	20, 0	32, 4	
		C	160-180	4, 8	"	"	Not det'd.	2, 8	Not det'd.	2, 8	15, 0	84	"	0, 5	"	3	21, 5	34, 1	
7 ^T	Sod moderately-podzolic coarse clay loam; spruce forest with aspen, 1100 m to the w. of the southern limit of Osinovka	A ₀	0-5	4, 1	2, 7	0, 09	4, 9	1, 3	4, 9	8, 4	3, 2 ^b	28	2, 2	1, 0	4, 1	56	10, 3	22, 2	
		A ₁	5-10	4, 1	Not det'd.	Not det'd.	4, 9	1, 3	3, 7	6, 4	1, 5	19	1, 6	Not det'd.	"	23	5, 4	18, 0	
		A ₂	22-27	4, 2	0, 5	0, 01	4, 2	6, 3	2, 9	3, 0	2, 4	44	6, 8	0, 8	0, 7	11	22, 1	31, 0	
		B ₁	40-45	4, 2	0, 2	0, 02	5, 8	7, 5	5, 6	4, 1	8, 0	66	4, 2	1, 2	1, 0	20	—	—	
		B ₂	85-90	4, 2	0, 4	Not det'd.	Not det'd.	4, 8	4, 8	4, 2	6, 0	59	5, 4	1, 8	1, 5	12	17, 5	24, 5	
		C	150-155	4, 1	0, 2	"	"	"	4, 8	3, 4	7, 6	69	"	2, 2	1, 0	12	—	—	
11	Sod strongly-podzolized coarse clay loam; spruce forest, 3 km to the n. w. of the northern limit of Potapovo	A ₀	0-3	3, 9	6, 0	0, 40	14, 4	1, 0	15, 8	10, 5	8, 6	45	6, 7	1, 9	3, 5	29	12, 5	26, 0	
		A ₁ A ₂	3-8	4, 1	1, 2	0, 07	4, 1	15, 0	2, 7	3, 6	1, 9	35	1, 4	0, 5	1, 5	43	6, 0	16, 2	
		A ₂ B	12-17	4, 1	0, 4	0, 04	3, 5	15, 0	2, 6	3, 5	2, 4	41	1, 7	0, 7	1, 5	38	11, 6	18, 6	
		B ₁	26-31	4, 2	0, 6	0, 04	3, 0	10, 0	6, 5	6, 9	5, 1	43	3, 9	1, 2	4, 4	46	21, 5	27, 4	
		B ₂	40-45	4, 2	0, 4	Not det'd.	Not det'd.	Not det'd.	Not det'd.	5, 8	7, 6	57	4, 7	2, 9	3, 1	29	18, 0	29, 1	
		C	70-75	4, 0	0, 4	Not det'd.	Not det'd.	7, 5	"	3, 6	9, 8	78	6, 6	3, 2	1, 2	11	18, 9	32, 3	
			120-140	3, 8	Not det'd.	Not det'd.	Not det'd.	"	"	"	"	"	"	"	"	"	"	"	"

³In all the table the level of saturation with bases is calculated from hydrolytic acidity.

^bHere and below we give the total of Ca + Mg.

Analysts: Konovalova, Smirnova, Shermukova, Berman.

Note: Comma represents decimal point.

Table 2
Chemical and particle-size analyses for slightly cultivated sod-podzolic soils^a

Profile No.	Soil and location	Hori- zon	Depth, cm	pH in KCl extract	Humus, %	Total nitrogen, %	Easily hydroly- zable nitrogen	Easily soluble nitrogen P ₂ O ₅	Ex- change- able potas- sium (K ₂ O)	Hydro- lytic acid- ity	Total of exchange- able bases (Ca+Mg)	Degree of base saturation, %	Exchangeable cations (Gedroyts method), meq			Total ex- change- able cations	Particle diam	
													Ca	Mg	H		Clay <0.001 mm	Physi- cal clay
303	Sod weakly-podzolic coarse clay loam of medium thickness. 1300 m to the n. of the northern limit of Pota- povo.	A ₁	0-5	4,6	1,6	Not det'd.	2,8	7,5	7,8	3,5	8,4	70	6,3	2,1	0,4	5	19,4	29,7
		A ₁	15-20	4,6	1,5	"	3,6	7,5	7,9	3,4	9,2	73	6,2	3,0	0,4	4	19,5	30,8
		B ₁ (A ₂)	25-30	4,5	0,7	"	2,8	7,5	6,0	3,2	10,6	77	7,8	2,8	0,4	3	22,3	30,6
		B ₂	55-60	4,4	0,7	"	Not det'd.	7,5	6,4	3,2	9,1	74	6,6	2,5	0,6	6	22,9	31,6
		B ₂	140-145	4,5	0,5	"	"	7,5	6,7	3,1	13,2	81	8,5	4,7	0,4	3	22,0	34,8
631C	Sod moderately-podzolic coarse clay loam to medium thickness. Old plowed field. Oats. 300 m s. w. of the western limit of Kokhanovo.	C	195-200	5,2	0,5	Not det'd.	"	20,0	Not det'd.	Not det'd.	11,7	—	8,2	3,5	0,2	2	20,7	31,6
		A ₁	0-5	4,8	2,5	Not det'd.	Not det'd.	2,5	9,3	4,9	5,7	54	4,0	1,7	0,9	14	11,9	24,0
		A ₁	20-25	4,8	2,1	"	"	2,5	5,8	4,9	5,1	51	4,4	1,0	1,2	19	11,5	24,1
		A ₂	28-33	4,5	0,5	"	"	20,0	2,5	3,1	3,1	50	1,9	1,2	0,6	16	9,8	17,4
		B ₁	38-43	4,4	0,5	Not det'd.	Not det'd.	20,0	4,8	3,7	8,4	70	6,1	2,3	0,9	10	18,7	30,2
1441	Sod strongly-podzolic coarse clay loam, shal- low. 1000 m s. s. w. of the southern limit of Ivishenka.	B ₂ g	90-95	4,0	0,0	"	"	Not det'd.	Not det'd.	Not det'd.	Not det'd.	—	Not det'd.	Not det'd.	0,8	—	14,0	24,3
		C	145-150	3,6	0,6	"	"	Not det'd.	4,5	3,4	6,3	65	3,6	2,7	0,7	11	15,3	25,5
		A	0-5	4,8	2,1	Not det'd.	Not det'd.	12,5	7,3	5,5	4,3	44	3,2	1,1	0,7	14	Not det'd.	"
		A ₁ A ₂	14-19	4,7	0,7	Not det'd.	Not det'd.	10,0	6,6	5,4	—	—	Not det'd.	Not det'd.	0,7	26	"	"
		A ₂ (g)	27-32	4,5	0,3	Not det'd.	Not det'd.	25,0	3,0	5,6	2,5	44	2,1	0,4	0,9	29	"	"
		B ₁	60-65	4,2	0,2	Not det'd.	Not det'd.	17,5	9,0	5,6	6,9	55	5,0	1,9	2,9	29	"	"
		C	135-140	4,1	0,1	"	"	17,5	9,8	4,6	10,8	70	6,3	4,5	2,7	20	"	"

Analysis by Snitsyna, Smirnova, Shershukova and Golovina.

^aIn this and the following tables the following methods were used: humus, Tyurin; total nitrogen Tyurin; total nitrogen Tyurin; easily soluble P_2O_5 , Kirsanov; exchangeable potassium, Vasilova; particle size, Kachinskiy.

Note: Comma represents decimal point.

DIAGNOSTIC INDICES OF SOD-PODZOLIC SOILS

tory explanation).²

Comparison of sod-podzolic virgin and slightly cultivated soils — of the same species reveals considerable differences in their chemical properties and shows that they must be separated on the soil map. At the moderately cultivated stage these differences are even more marked.

Analytical data for moderately-cultivated³ d-podzolic coarse clay loams are given in Table 3. The chemical indices for all three soil species (weakly-, moderately- and strongly-podzolic) are much closer together. Exchangeable hydrogen does not exceed 3% of the exchangeable cations in all three soils. In addition to the general increase in the total of exchangeable cations, the following ratio holds for all three soils

$$\frac{\text{Ca} + \text{Mg (in } A_1 \text{ hor.)}}{\text{Ca} + \text{Mg (in the parent material)}} > 1.$$

Some residual features of podzol formation are however retained in the moderately- and strongly-podzolic soils — the total of exchangeable bases and the adsorption capacity are noticeably reduced in the A_2 horizon (profile 1073). Residual features are also retained in the illuvial horizon.

The differences between slightly and moderately cultivated sod-podzolic soils are thus clearly seen. The highly typical features of moderately cultivated soils are: a) increase in humus content and considerable accumulation of exchangeable bases in horizon A_1 , which normally exceeds the amount of exchangeable bases in the parent material; b) a marked decrease in the easily soluble phosphates and exchangeable potassium in the upper 30–40 cm, sometimes in a thicker stratum in which acidity is considerably reduced: pH (KCl extract) reaches 4.7–5.5. This points to residual podzol formation.

The differences between slightly and moderately cultivated sod-podzolic soils are clearly seen from the data on crop yields in Table 4.

As the degree of cultivation increases, distinctions in the morphology and chemical properties of sod-podzolic soils of different species becomes more marked and this also affects crop yields. Consequently, cultivation utilizes the soil background and levels out variations in the soil.

Soil heterogeneity is completely eliminated in soils are well cultivated and the properties of sod-podzolic soils are so changed that they should be assigned to a different subgroup.

Data from Konovalova's study (6) of the properties

is also occurs in virgin soils.

Profile 1100 — sod residual weakly-podzolic soil; A_2 missing. Profile 5^T — residual moderately-podzolic; hor. A_2 discontinuous — as "pockets" and [a]. Profile 1073 — residual strongly-podzolic hor. A_2 continuous, sharply delineated, thicker than 10 cm.

erties of well cultivated coarse clay loam sod-podzolic soil of medium thickness are given in Table 5. The following morphological changes occur in sod-podzolic soils when they are cultivated:

a) the thickness of the A_1 horizon increases and it becomes darker in color; b) the structure of the A_1 horizon changes from unstable blocky (powdery) in virgin and slightly cultivated soils to blocky-granular in well cultivated soils; c) the thickness of the A_2 horizon decreases and it disappears entirely when the soil is well cultivated. At this stage the B_1 horizon also becomes less clearly defined.

Konovalova's data will be published in a special paper and we shall here consider only her analytical results for well cultivated soil (Table 5).

Above all it should be noted that hydrogen is practically absent from the exchangeable cations when the soil is well cultivated. The total exchangeable bases (Ca + Mg) in the A_1 horizon rises sharply to levels (19 meq) that are unusual in less well cultivated sod-podzolic soils. Other typical features are a high content of exchangeable bases in a considerable thickness of the soil and the absence of a clearly defined maximum in the B_1 horizon. Saturation with bases reaches 80%–90%. There is a considerable increase in the total content of humus, which is twice as high as in virgin soil in the first 20 cm of a well cultivated soil. There is also a change in the qualitative composition of the humus (6). The carbon ratio of the humic to fulvic acids is 0.68 in virgin sod-podzolic soil; almost the same at 0.63 in slightly cultivated soil; 0.89 in moderately cultivated soil and 1.09 in well cultivated soil.

The typically high level of exchangeable potassium and easily soluble P_2O_5 in a fairly thick layer of well cultivated soils is probably associated with "deepening" of the process of forming a cultivated soil, with increase in the thickness of the soil layer involved in the minor biological soil cycle in which the elements of plant nutrition are firmly retained.

These data show that the process of soil formation has been fundamentally affected.

Owing to man's purposeful intervention (by melioration, use of fertilizers, farming practices, etc.) the agricultural crop that is planted changes the morphological pattern and physico-chemical properties of virgin sod-podzolic soils, which progress through various stages of cultivation to form a new subgroup of "sod cultivated" (well cultivated) soils.

Thus, since the cultivation of sod-podzolic soils leads to a gradual reduction in the process of podzol formation and finally to its total elimination, the degree of cultivation of soils can be described both in terms of the degree of development of the sodding process and, especially in the initial stages, by the degree to which the process of podzol formation is "inhibited." This enables one to give "diagnostic outlines" of sod-podzolic soils at differing levels of cultivation. The following levels can be distinguished:

Table 3

Chemical and particle-size analyses for sod-residual-podzolic soils, moderately cultivated

Pro- file No.	Soil and location	Hori- zon	Depth, cm	pH, salt	Humus %	Total nitro- gen, %	Easily hydro- lyz- able nitro- gen	Exch. potas- sium (K ₂ O)	Hydro- lytic acid- ity	Total of exch-ange- able bases (Ca + Mg)	De- gree of base satur- ation, %	Exch. cations (Gedroyts' method)				H as a % of the exch-ange- able cations	Particle diameter	
												Ca	Mg	H	In meq		Clay	Phy- sical clay
1100	Sod residual weakly- podzolic coarse clay loam of medium thickness	A ₁	0-10	5,5	2,5	Not det'd.	25,0	13,2	5,1	9,5	65	7,5	2,0	0,3	3	Not det'd.		
		A ₁	14-24	5,4	1,8	"	20,0	12,6	3,8	9,9	72	7,5	2,4	0,2	2	"		
		B ₁	25-30	5,1	1,0	"	25,0	21,0	2,7	11,9	81	7,8	4,1	0,2	1	"		
		B ₂	70-80	5,6	Not det'd.	Not det'd.	25,0	43,2	—	6,7	—	4,5	2,2	0,2	3	"		
		C	150-160	6,1	2,6	0,88	25,0	64,8	1,3	8,0	85	5,8	2,2	0,3	3	"		
5	Sod residual moder- ately-podzolic coarse clay loam of medium thickness. 800 m from the southern limit of Kuz'mino to the s. w.	A ₁	0-5	4,4	2,6	0,88	25,0	23,4	2,6	8,6	77	7,0	1,6	0,7	1	14,9	24,3	
		A ₁	15-20	4,6	0,3	0,02	15,0	30,7	3,0	7,4	80	5,5	1,9	0,2	3	—	17,6	24,7
		A ₁ BA ₂	25-30	4,9	0,3	0,02	25,0	30,7	1,8	8,2	78	6,0	2,2	0,2	2	—	20,1	28,3
		B ₁	40-45	4,9	0,3	0,02	20,0	28,9	2,3	7,3	75	4,9	2,4	0,2	3	—	—	—
		B ₂	80-85	4,2	0,2	Not det'd.	Not det'd.	39,1	2,4	7,5	77	3,7	3,8	0,2	3	—	18,2	26,5
1073	Sod residual strongly- podzolic coarse clay loam of medium thickness. 1100 m to the south of the south- ern limit of Ivishenka	C	145-150	4,4	—	Not det'd.	25,0	37,3	2,2	9,5	61	7,6	1,9	0,2	2	Not det'd.		
		A ₁	0-10	5,1	3,2	"	25,0	40,0	5,9	9,5	70	8,0	1,5	0,1	1	"		
		A ₁ (A ₂)	18-28	5,2	2,2	"	25,0	8,3	4,0	9,5	78	3,9	3,6	0,2	3	"		
		A ₂	30-35	4,9	1,4	"	25,0	7,0	2,0	7,5	80	7,0	3,7	0,5	4	"		
		B	50-60	4,7	—	"	25,0	30,0	2,7	10,7	82	6,3	3,1	0,4	4	"		

Analysts: Konovalova, Smirnova and Golovina.

Note: Comma represents decimal point.

Grain yield on cultivated sod-podzolic soils^a

Slightly cultivated soils	Grain yield cntr/hab	Relative value	Moderately cultivated soils	Grain yield cntr/hab	Relative value
Sod strongly-podzolic	$\frac{4-12}{8}$	1,0	Sod strongly-podzolic	$\frac{12-20}{16}$	2,0
Sod moderately-podzolic	$\frac{4-15}{9,5}$	1,2	Sod moderately-podzolic	$\frac{12-24}{18}$	2,2
Sod weakly-podzolic	$\frac{5-19}{12}$	1,5	Sod weakly-podzolic	$\frac{14-26}{20}$	2,5

^aThe crop yield data were obtained and processed by I. S. Stepanov, a laboratory assistant.
^bThe mean yield is shown in the denominator.

Note: Comma represents decimal point.

Table 5

Chemical and particle-size analyses for well cultivated sod-podzolic soil (sod cultivated)

Profile No. and location	Hori- zon	Depth, cm	pH		Humus, %	Total nitro- gen	Easily hydro- lyzable nitro- gen	Exch. Easily soluble P ₂ O ₅	Exch. potas- sium (K ₂ O)	Hydro- lytic acid- ity	Total ex- change- able bases		Degree of base satur- ation, %	Exchangeable cations (Gedrovis' method)			H as a % of total exch.	Particle diameter — <0.001 <0.01 In %	
			Water	Salt							In meq	Ca		Mg	H				
Profile 8, 200 m to the west of the northern limit of Kuz'mino, Orchard 70-80 yr. ago	A ₁	0-5	6,3	5,3	3,5	0,24	11,5	25,0	93,9	1,8	18,9	91	14,8	4,0	0,1	1	15,0	25,5	
	A ₁	15-20	6,3	5,0	Not det'd.	Not det'd.	Not det'd.	20,0	80,1	1,9	Not det'd.	—	Not det'd.	Not det'd.	Trace	—	Not det'd.	22,0	31,0
	A ₁ B	27-32	5,7	5,0	0,6	0,07	7,0	25,0	45,2	2,4	13,6	85	6,8	6,8	0,1	0	24,9	31,3	
	B ₁	45-50	5,0	4,4	0,3	0,05	5,0	25,0	45,1	2,6	12,4	83	7,6	4,8	0,1	1	24,9	31,3	
	B ₂	80-85	5,2	4,3	0,3	0,05	5,0	25,0	44,5	3,1	9,6	76	5,6	4,0	0,4	4	Not det'd.	Not det'd.	
	C	150-155	5,6	4,6	0,2	Not det'd.	"	Not det'd.	69,2	1,7	8,8	84	3,6	3,6	3,6	0,1	1	18,4	29,6

Analyst: Konovalova. Particle-size analysis by Berman.
Note: Comma represents decimal point.

1. Slightly cultivated soils that retain the features of virgin soils, but in which there are clearly defined indications of the slowing down or inhibition of the process of podzol formation.

2. Well cultivated soils in which the sodding process is clearly defined.

3. Moderately cultivated soils are a transitional stage between the first two. There is a general tendency for soil formation to proceed according to the sodding process, but certain residual features of podzol formation can still be seen.

Three species (three levels) of cultivated soils are therefore distinguished:

1. Slightly cultivated sod-podzolic soils.
2. Moderately cultivated sod residual podzolic.
3. Sod cultivated (well cultivated) sod-podzolic.

The possible genetic link between these species is shown in the working classification shown in Figure 1.

One can distinguish two trends in the cultivation of sod-podzolic soils: suppression of the process of podzol formation and development and intensification of the "sodding" process until

podzol formation is completely eliminated and 2) "deepening" of the process of forming a cultivated soil — by which the minor biological cycle embraces an ever greater thickness of the parent material.

The main diagnostic indices for the species of sod-podzolic cultivated soils here distinguished are given in Table 6.

Conclusions

1. Since cultivation processes considerably affect the chemical properties of sod-podzolic soils in a short time, a distinction must be made in field cartography between special cultivated variants of these soils and virgin soils, even if they belong to the same soil species and variety.

2. Sufficiently clearly cultivated sod-podzolic soils can be divided into three levels (species) of cultivation by their morphological features and chemical properties: 1) slightly cultivated, 2) moderately cultivated (residual podzolized) and 3) well cultivated (sod cultivated).

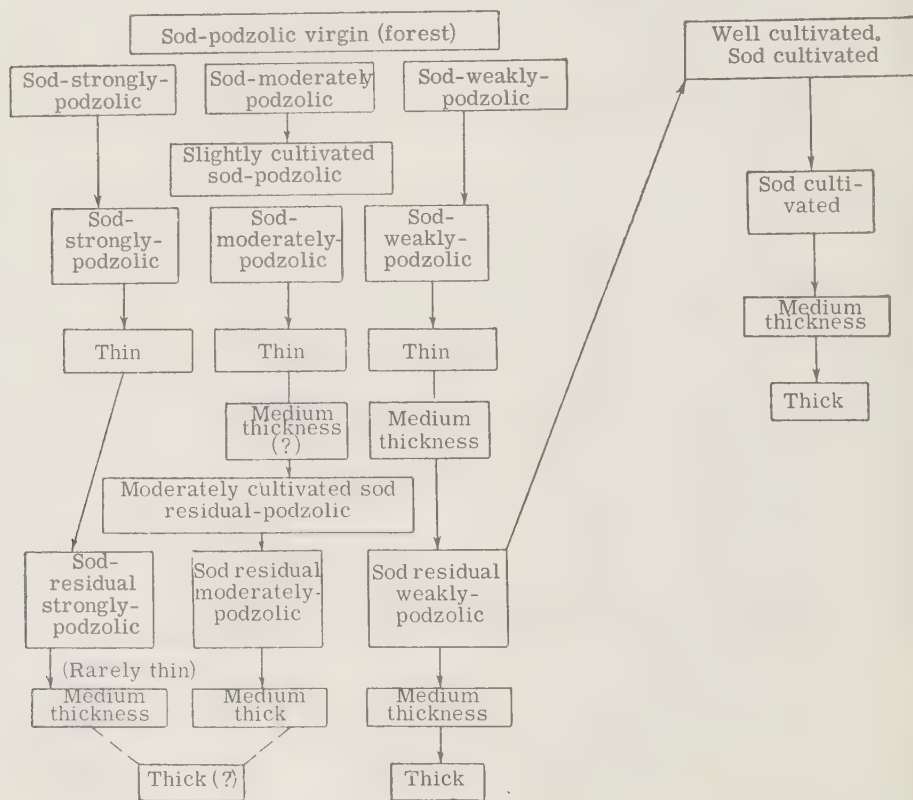


Fig. 1. - Scheme for classification of cultivated sod-podzolic soils

Thin - $A_1 < 20$ cm; medium - $A_1 = 20-23$ cm; thick - $A_1 = 25-35$ cm and greater.

DIAGNOSTIC INDICES OF SOD-PODZOLIC SOILS

Table 6

Diagnostic indices for sod-podzolic coarse clay loam soils at different levels of cultivation

Species of cultivated sod-podzolic soils	Soil variety by thickness of A ₁ hor.	Structure by thickness in cm and color of A ₁ hor.	A ₂ hor. thickness in cm, nature of humus %	pH, salt in the upper 30-40 cm	P ₂ O ₅ easily soluble (K ₂ O) In mg per 100 g	Hydrolytic acidity		Total exchange, bases	Degree of base saturation, %	Exchangeable bases	Nature of the distribution of exchange. bases (Ca + Mg)	Ratio of the humic acids C of the fulvic acids	Nature of soil and local relief	Grain yield in live units
						In meq	In meq							
Slightly cultivated														
Sod strong-podzolic	Thin	Unstably blocky or powdery <20, light grey	10 and greater; continuous with deep tongues	2,0-2,7	4,0-4,3	5, rarely 10 mg	10, In A ₁ hor.; abruptly drops in A ₂ hor.	In A ₁ 5-7; In A ₁ greatly reduced in A ₂ ; increases sharply; in B ₁ greatly increased in B ₁	40-50	15-25 rarely below	No data			1,0
	"	The same	3-6 (10); often tongues	4,8-2,5	4,0-4,3	The same	10; abruptly diminished in A ₂ hor.	In A ₁ 3-7; In A ₁ greatly reduced in A ₂ ; increases sharply in B ₁	45-55	10-15 rarely below	0,6-0,7	Clearly defined heterogeneity; local relief somewhat smoothed		1,2
Sod weakly-podzolic	Thin-Medium	<20 Structure and color the same	Absent or small lenses and spots	4,5-2,1	4,4-4,7	"	7-10; equally distributed throughout the profile	2-4, uniformly distributed throughout the profile	55-70	3-5 rarely 10	No data			1,5

Medium cultivated

Sod residual strongly podzolic	Medium	Blocky, 20-25, grey	6-10 and greater; with wedges (tongues) 2-8; often discont. some times tongues	2, 0-3, 0	4, 6-5, 1	20	8-20 and greater; falls consid. in A ₂	In A ₁ 4-6; 7-10; greatly decreased in A ₂ ; in B ₁ increases.	60-75	3-5	$\frac{Ca + Mg - in hor A_1}{Ca + Mg - in parent material} < 1$	0, 7	2, 0
Sod residual moderately podzolic	Medium	The same		2, 0-3, 0	4, 6-5, 1	20	15-20 and greater	In A ₁ 2-5; greatly reduced in A ₂ ; in B ₁ increases in B ₁	70-80	3 and less		0, 9	2, 2
Sod residual weakly podzolic	Medium Thick	20-25 25-35; Struc-ture and color the same	Absent, some times SiO ₂ powdering	2, 0-3, 0	4, 7-5, 5	20-30	15-20 and greater	In A ₁ 2-5; uniformly distributed throughout the profile	70-80	3 and below		No data	2, 5
Sod cultivated	Medium Thick	20-25 25-35 Stable small block, rarely granular, dark grey	Absent, possibly isolated tongues	3, 0-5, 0 (to 6, 0)	5, 0-6, 5 and greater	> 30	> 30	1, 5-2, 5, slightly increased in B ₁	80-90	usually less than 1	$\frac{Ca + Mg - in hor A_1}{Ca + Mg - in parent material} > 1$	> 1	No heterogeneity; local relief greatly smoothed

Note: Comma represents decimal point.

DIAGNOSTIC INDICES OF SOD-PODZOLIC SOILS

The division of sod-podzolic soils into these levels of cultivation is of great practical importance, since there are considerable differences in productivity.

3. When mapping sod-podzolic soils at differing levels of cultivation, one of the guiding principles should be the state of the agricultural crop plant. In particular, extensive spottiness of crops is always an indication that the soils are only slightly affected by cultivation.

The use of aerial photographs is of extreme importance when mapping cultivated soils, since they give a clear indication of spottiness, varying moisture, humification and other factors.

4. The following analyses are essential to establish the level of cultivation of sod-podzolic soils: determination (by genetic horizons) of exchangeable cations (Ca, Mg, H), hydrolytic acidity, pH (in KCl), easily soluble phosphates and exchangeable potassium and sodium.

Received December 21, 1959

BIBLIOGRAPHY

1. BLAGOVIDOV, N. L. 1948. The cultivation

of podzolic soils. Tr. Pochv. in-ta, Vol. 27.

2. BLAGOVIDOV, N. L. 1954. The fundamentals of the cultivation of podzolic soils. Pochvovedeniye, No. 2.

3. VAZHENIN, I. G. 1957. Chemical characteristics of sod-podzolic soils at differing levels of cultivation in the Kaliningrad region. Pochvovedeniye, No. 6.

4. ZAVALISHIN, A. A., and B. V. NADEZH-DIN. 1952. On the transformation of forest podzolic soils by a crop. Pochvovedeniye, No. 11.

5. ZAVALISHIN, A. A. and B. V. NADEZH-DIN. 1957. The study of contemporary soil formation in the west of the Russian plains. In: Sbornik rabot Tsentral'nogo muzeya pochvoved. im. V. V. Dokuchayeva No. 11.

6. KONOVALOVA, A. S. 1958. Comparative description of sod-podzolic virgin and cultivated soils. Mss. Biblioteka pochvoved. instituta im. V. V. Dokuchayeva Akad. Nauk SSSR.

OXIDATION-REDUCTION POTENTIAL PROFILE CURVES IN RELATION TO THE CONDITIONS OF SOIL FORMATION

I. YA. SELL'-BEKMAN, V. A. RABINOVICH, and O. V. KUROVSKAYA, Northwestern Agricultural Research Institute

We have shown in a previous paper (1) that the oxidation potential (Eh) profile curve differs for soils of different genesis and can therefore be used as a distinguishing feature of the course of the soil-forming process. A minimum of the oxidation potential in the lower part of the A₁ horizon is a typical feature of the gley subtype, while there is a more or less clearly defined maximum on the profile curve for normally moist soils. McKenzie and Erickson (5) obtained similar results in a study of three soil profiles.

The effect of some of the conditions of soil formation on the nature of the Eh profile curve is considered in this paper. Direct field measurements were made of the oxidation potential throughout the soil profile in the Mginsk district of the Leningrad region using platinum coated glass electrodes and a method already described (4). The measurements were repeated five times and the divergence did not normally exceed 15-20 mv.

Eh profile curves for the subtype of excessively wet virgin soils are given in Figure 1.

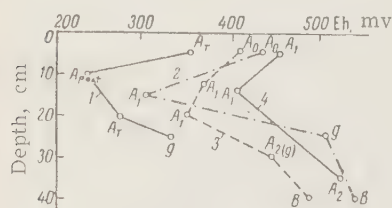


Fig. 1 - Change in oxidation potential in relation to the development of gleying in podzolic soils on noncarbonate moraine clay loam. ("Zarya kommunizma" kolkhoz, 18-21 May, 1955).

1 - profile 8. Peat-humus-gley soil, grass-horsetail-sedge meadow; 2 - profile 12. Sod-podzolic-gley soil, hair grass meadow; 3 - profile 10. Peaty podzolic-gley soil, mat grass meadow with hydnium mosses; 4 - profile 3. Sod-podzolic soil with some signs of gleying, mat grass-motley grass meadow.

These measurements were made simultaneously in fine warm spring weather, and soils of similar texture in similar situations (except profile 8, lying further down the slope) were selected. These observations confirm the earlier conclusion (1) that in excessively wet soils the Eh profile curve has a typical minimum in the A₁ horizon, the accentuation of which is directly dependent on the degree of gleying.

In addition to confirming the level of reduction processes in soils as deduced from morphological characteristics, measurements of the oxidation potential can also be used to determine when and to what extent reduction processes develop in soils and also to reveal differences in this respect between soils that are much alike in their morphological and genetic features. This is of particular interest for soils with a variable water regime and for soils that are becoming water-logged or have been drained.

A soil with a fluctuating water regime is shown in Figure 2. This is a sod-podzolic coarse clay loam, slightly cultivated soil, on a poorly drained level area, which becomes excessively wet from time to time. In 1952 perennial grasses were sown after winter rye, but the grasses died on sectors with this soil; velvet bentgrass (*Agrostis canina*) was grown here in 1953-1954.

Despite the periodic excessive wetting, small isolated ortsteins in the A_2 horizon are the only morphological indication of gleying. It is therefore impossible to determine the period at which reduction processes develop from morphological observations. The oxidation potential profile curve is also subject to considerable change in the course of the season. In October its form is typical of that for soils in which reduction processes predominate, in midsummer it is typical of normally moist podzolic soils and in May it varies with the conditions for the year (1953 had an early dry spring).

Thus, observations of Eh profile curves revealed that reduction processes in this soil occur mainly in autumn excessive wetting and to a far lesser extent in the spring. It also follows from these data that a correct understanding of the oxidation-reduction regime of any soil must be based on measurement of its oxidation potential throughout the whole growing season; the

OXIDATION-REDUCTION POTENTIAL PROFILE CURVES

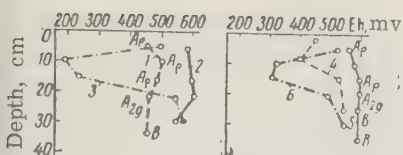


Fig. 2.- Seasonal changes in the oxidation potential profile curve of a sod-podzolic coarse clay loam soil with variable water regime (profile 7, "Druzhnyy trud" kolkhos).

1 - May 29, 1953; 2 - June 24; 3 - October 30; 4 - May 8, 1954; 5 - June 11; 6 - October 29.

ure of the Eh profile curve can be affected h by the season and by variations from year year in hydrothermal conditions.

It should be noted that the predominant rection processes in the autumn are not general soils with a fluctuating water regime. In ticular, plowing can basically affect the onal dynamics of oxidation potential profile ves. Profile curves for temporarily exces- sely wet cultivated soils that were similar in esis, texture and layering conditions are en in Figure 3. Since these soils are under- ivated silty clay loams, they swell easily n excessively wet and form a crust, and er lies in puddles on their surface. Plowing ates a normal air and water regime in the y making it more permeable.

n 1954, when there was a late cold spring

and a very damp second half of the summer, various crops were grown on these soils and they were plowed at different times. This gave rise to differences in the dynamics of the Eh profile curves on the different fields. The soil in profile 98 (Fig. 3a) in a field of winter rye was excessively wet in the spring, but only slightly moist in August after the harvesting of a good winter crop. The Eh profile curve there- fore showed that reduction processes predomi- nated here in May, while in August it was simi- lar to the curves typical of normally moist podzolic soils.

The soil around profile 22 in a field of spring wheat, on the other hand, was ripe in May, but excessively wet in August, after prolonged driz- zle and a sub-flow of water from higher up the slope in the almost total absence of vegetation (the wheat died). Puddles accumulated and there was a smell of hydrogen sulfide when a profile was dug in the A_p horizon. In this case, (Fig. 3b) the Eh profile curve in May was that of a normally moist podzolic soil, but reflected the great development of reduction processes in August.

The curves for a newly plowed podzolic soil (profile 24) in the same field of spring wheat as profile 22 and with no signs of gleying in the pro- file confirm that this difference in the dynamics of the Eh profile curves in profiles 98 and 22 is due above all to the period at which the soils were worked. Figure 3c shows that the seasonal dynamics of the profile curve in it are of a similar nature to those in the gley soil, al- though the Eh minimum in August is much less marked.

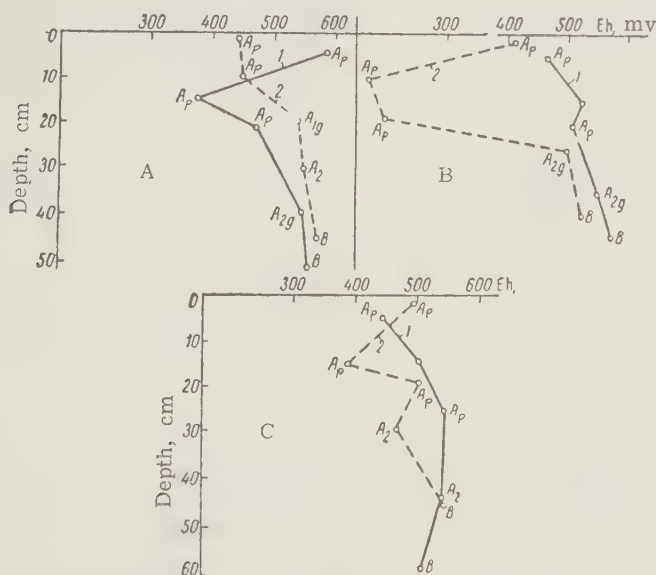


Fig. 3.- The effect of cultivation on the oxidation potential in soils of variable wetting ("Zarya kommunizma" kolkhos, 1954)

Sod-podzolic coarse clay loam soil. A - profile 98. Lower part of a very gentle slope, winter crops 1953; B - profile 22. Foot of steep slope, newly plowed, spring wheat on spring plowing; C - profile 24. Middle of slope in same field; 1 - May 23; 2 - August 25-27.

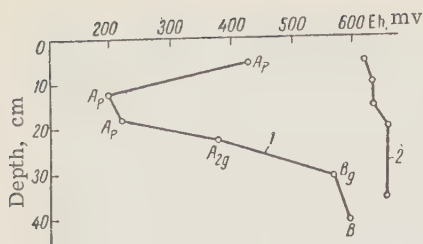


Fig. 4. - The effect of a slight elevation on the oxidation potential of the soil ("Druzhnyy trud" kolkhoz, October 30, 1953)

1 - profile 6. Sod-podzolic-gley coarse clay loam soil on a level poorly drained plain; 2 - section 6a. Slight elevation on the same plain.

Oxidation potential curves also show that there is a difference between excessively wet soil by stagnant waters and by oxygen-rich atmospheric precipitation; reduction processes develop much more intensively in the first case. Figure 4 shows the oxidation potential curves for a sod-podzolic gley soil on a flat poorly drained plain and on a slight elevation in the same plain. The measurements were made in the autumn after a long period of drizzle, when both soils were saturated with water. The

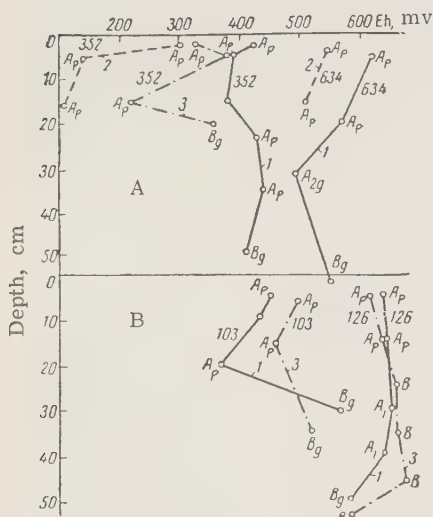


Fig. 5. - Effect of a slight depression on the oxidation potential of excessively wet soil ("Zarya kommunizma" and "Druzhnyy trud" kolkhozes); A - April-May; B - August.

1 - level areas; 2 - saturated depressions; 3 - normally wet depressions. Soils under winter rye: profile 634 - sod-podzolic-gley coarse clay loam, May 8, 1952; profile 352 - dark sod clay loam, April 23, 1953; profile 103 - dark sod clay loam, August 27, 1953. Soil under potatoes: profile 126 - dark sod clay loam, August 12, 1952.

oxidation potential curves show however that reduction processes were greatly developed where the soil was wetted by stagnant water on the level surface.

The oxidation potential in slight depressions and on a level surface on dark sod, sod-podzolic gley and sod-podzolic soils was compared to reveal the effect of excessively wet soils of different genesis on the Eh profile curve. The oxidation potential was found to be lower in the slight depressions on dark sod soils during periods of excessive wetting than on level sectors (Fig. 5a). The same thing was observed in depressions on sod-podzolic-gley and occasionally on sod-podzolic soils that had been saturated for a considerable period. Nevertheless, saturated areas in which plants die on sod-podzolic soils normally have approximately the same Eh value as the main body of the soil. In dry periods, when the soils dry out, the Eh value in slight depressions on dark soddy (and sod-podzolic) soils is the same as or slightly above that in the body of the soil (Fig. 5b).

The explanation for these differences is clear that when humus content is relatively low, the comparatively brief saturation of depressions on sod-podzolic soils does not cause any marked development of reduction processes, whereas these processes are much more developed in depressions containing dark sod and sod-podzolic-gley soils that are saturated for a longer period. One would therefore expect ferrous iron to be accumulated in depressions of dark sod but not of sod-podzolic soil. This assumption has been confirmed by direct field tests for ferrous iron using potassium ferricyanide. The largest quantities of ferrous iron were detected in depressions on dark sod soils and the next largest on sod-podzolic-gley soils; no ferrous iron was detected in sod-podzolic soils that had been saturated for a short period.

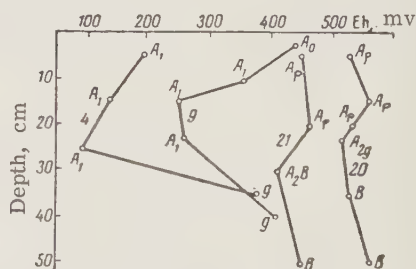


Fig. 6. - Oxidation potential of soils formed on various parent materials ("Zarya kommunizma" and "Druzhnyy trud" kolkhozes).

Normally moist soils, May 30, 1953; profile 21 - sod-carbonate clay loam, clover; profile 20 - sod strongly-podzolic gravel clay loam, winter crop. Excessively wet soils, virgin meadow, May 18, 1955, profile 4 - dark sod on carbonate moraine clay loam; profile 9 - peaty humus soil on noncarbonate clay loam.

OXIDATION-REDUCTION POTENTIAL PROFILE CURVES

It has previously been suggested (3) that the decrease in the oxidation potential in the soils of low depressions after drying out is probably connected with a reduction of microbiological activity in the soil. In their study of peat-bog soils Lupinovich and his colleagues (2) found that the oxidation potential was inversely proportional to biological activity.

The oxidation-reduction conditions that develop in a soil are dependent on the nature of the parent material as well as on the water-air regime of the soil. Figure 6 shows that the oxidation potential of soils formed on carbonate parent materials is 150-200 mv lower than in soils not saturated with bases in which the moisture factors are similar. It is probable that this is due to the higher biological activity of high humus base-saturated soils.

Conclusions

1. Simultaneous measurements of oxidation potentials throughout the profile of virgin soils confirm a relationship between the nature of the oxidation potential profile curve and the degree of gleying and water-logging of the soils; when reduction processes in the soil are intensified there is a general shift to the left in the Eh profile curve and the Eh minimum in the lower part of the A₁ horizon becomes more definite.
2. The periods at which reduction processes dominate and the intensity of their development can be established in soils with a changing water-air regime by measuring the oxidation potential.
3. Measurements of the oxidation potential enable one to reveal the differences in the oxidation-reduction conditions of morphologically

similar soils that are due to the nature of the wetting (stagnant or running water, poor or rich in oxygen), the positioning of the soil in the local relief and the time of cultivation.

4. The value of the oxidation potential in the soil depends on the parent material as well as on the moisture. Soils formed on a carbonate parent material have a lower oxidation potential than those under similar moisture conditions that are not saturated with bases.

Received February 25, 1959

BIBLIOGRAPHY

1. BLAGOVIDOV, N. L., V. A. RABINOVICH, and I. YA. SELL'-BEKMAN. 1957. The nature of the changes in oxidation potential in the profile of certain soils in the Leningrad region. *Pochvovedeniye*, No. 6.
2. LUPINOVICH, I. S., I. N. SOLOVEY, and K. N. YANUSHKEVICH. 1958. Establishment of a connection between the values of the oxidation-reduction potential and biological activity in peat-bog soils. *Tr. Belorussk. n.-i. in-ta melioratsii i vodnogo kh.-va.* No. 8.
3. RABINOVICH, V. A. 1955. The relationship between the oxidation potential of the soil and the activity of soil microflora. *Dokl. Akad. Nauk SSSR*, Vol. 103:305.
4. RABINOVICH, V. A. and O. V. KUROVSKAYA. 1953. The use of platinum coated glass electrodes for field determinations of the oxidation-reduction potential of the soil. *Pochvovedeniye*, No. 4.
5. MCKENZIE, L. J. and A. E. ERICKSON. 1954. The use of redox potentials in studies of soil genesis. *Soil Soc. America Proc.* Vol. 18:481. In English.

RESPONSE OF CORN, SUGAR BEET, AND POTATOES TO CHANGES IN THE NUTRIENT REGIME OF THE SOIL AFTER CONTINUOUS APPLICATION OF FERTILIZERS¹

YU. K. KUDZIN, All-Union Corn Research Institute, Dnepropetrovsk

The systematic use of fertilizers, especially at high rates, substantially modifies several soil properties, nutrient regime, and interrelation of soil, fertilizers, and plants. Moreover, there often arises the need for nutrients hitherto absent, or a previously beneficial fertilizer is found to affect the plants adversely.

Thus, the results obtained in experiments on single-crop fields belonging to the Mironov Experimental Station of the All-Union Corn Research Institute are highly interesting. The experiments have been run from 1929 to the present. The soil is slightly leached chernozem, coarse clay loam on pale yellow coarse clay loam loess. Effervescence from hydrochloric acid is at 45-65 cm. The mean annual rainfall in the area is 461 mm. The experiment was replicated twice; the fertilized area of the plot was 480 m². Three crops were planted across all the plots: corn, potatoes, and sugar beet. The sown plot of each crop was 160 m², the yield plot, 100 m². According to the design of the experiment, fertilizers were applied annually after fall plowing in the form of ammonium sulfate, superphosphate, and potassium salt. The rates of application were changed at different times. The average amount used in the main treatments was 68 kg/ha of nitrogen, P₂O₅, and K₂O. In the NPK (st) treatment, nitrogen was applied annually at the rate of 40 kg/ha, P₂O₅ at 20 kg/ha, and K₂O at 40 kg/ha. Manure was added at the rate of 6 metric tons a year.

The result of continuous use of fertilizers in this experiment was that phosphorus had a pronounced adverse effect on corn and, in part, on the potatoes, especially during the last 10 years. The data on crop yield for the first and last two 5-year periods are presented in Table 1.

It is evident from these data that during the first 5 years corn responded well both to phosphorus alone and in combination with the other elements. Thereafter, but not every year, phosphorus had a sharp and persistently negative effect on corn whether used alone or in combination with nitrogen and potassium. In the NPK (st) treatment, where the amount of phosphorus was half that of nitrogen and potassium, and in

the NK and manure treatments, the fertilizers helped to increase the productivity of the crops. It is worth stressing that only the NK treatment resulted in a higher yield of corn and stalks during the last 5-year period than in the first.

Potatoes responded poorly to phosphorus alone beginning with the first 5-year period. The combination of two and three fertilizers increased the output considerably. This has continued until the present, but after NK the effectiveness of phosphorus terminated during the last 10 years and its influence from 1948-1957 on the yield of tubers was generally negative (in 7 out of 10 years).

Sugar beet, unlike the corn and potatoes, generally responded well to phosphorus alone throughout the experiment, although adverse effects were noted in an occasional year. Against an NK background phosphorus ceased, during the last 5 years, to have any effect on the yield of this crop too. The somewhat different response of sugar beet to fertilizers may be due not only to its specific biological qualities, but also to the fact that from 1936 on a complete mineral fertilizer was added to all the plots in which it was planted.

Thus, corn responds most sharply and negatively to intensified use of phosphorus. The simultaneous addition of equal amounts of nitrogen and potassium did not overcome the adverse effect of phosphorus.

This response of corn to phosphate does not show up at once. Even in the six-leaf phase, the plant—neither in external appearance nor in weight of aerial parts—reveals the effect of the fertilizers (Table 2).

Plants in plots fertilized with superphosphate eventually lag perceptibly in growth, even though there are no signs of deficiency or excess of any element. The only thing abnormal about plants on phosphate-fertilized plots is the rather rapid drying out of the lower leaves and absence of aerial roots. The external appearance of the plants when starting to tassel can be judged from Figure 1.

Our analyses of the soil in 1932, 1957, and 1958 show that continuous application of fertilizers had a marked effect on the phosphorous content and the solubility of its compounds (Table 3).

¹S. I. Gupalo, N. N. Goncharova, Z. K. Trzhetseskaya, and G. G. Farenik shared the analytic work.

CHANGES IN NUTRIENT REGIME

Table 1

Effect of fertilizers on yield of single-crops, cntr per ha

5-year periods	Number of re-corded years	Without ferti-liz-ers	Fertilizers						
			P	PN	NK	PK	NPK	NPK (st)	Manure
Corn—grain									
1930—1935	5	26,3	28,7	30,4	29,6	27,4	28,5	36,6	33,9
1948—1952	5	24,5	7,0	11,8	29,5	9,8	12,8	27,3	33,6
1953—1957	5	28,1	12,0	18,8	30,8	20,0	19,2	31,4	32,0
Potatoes—tubers									
1930—1935	5	107	87	109	122	115	140	145	125
1948—1952	5	59	51	85	163	78	149	80	74
1953—1957	5	46	36	78	124	62	127	69	65
Sugar beets—roots									
1930—1935	4	101	111	112	95	114	111	133	128
1948—1952	5	83	112	129	164	149	163	148	129
1953—1957	5	97	106	110	140	138	143	130	122

Note: Comma represents decimal point.

Table 2

Changes in weight of corn plants, weight of 100 air-dried plants, kg

Fertilizers	Time of analysis			
	6-leaf formation	8-leaf formation	Tasseling	Milk stage
Without fertilizers	0,03	0,17	4,80	11,67
P	0,03	0,13	2,02	6,25
NP	0,03	0,12	2,10	7,95
NK	0,03	0,21	5,85	13,45
PK	0,04	0,18	2,90	8,32
NPK	0,04	0,14	2,40	7,10
NPK (st)	0,04	0,27	6,75	13,05
Manure	0,04	0,26	7,50	14,10

Note: Comma represents decimal point.

During the 29 years of experiments with superphosphate some 2000 kg/ha of P_2O_5 were applied. It is easy to see from the data in Table 1 that about one-third of this amount accumulated in the soil of the plow layer in the form of readily-soluble salts passing into a carbonic acid extract and about half in compounds passing into a hydrochloric acid extract. It is noteworthy that the systematic addition of NK (ammonium sulfate and potassium salt) the content of total phosphorus and its soluble compounds is no lower, in fact it is somewhat higher, than in the treatment without fertilizers. We directed attention to this fact in connection with our analysis of the soil in field experiments of the Sumgaita Experimental Station (2).

Other indices (Table 4) include an increase in total and hydrolytic soil acidity following systematic application of ammonium sulfate ac-

companied by a small decrease in the content of absorbed calcium. There is a decrease in the content of humus and adsorbed bases as compared with the 1932 figures. The continuous use of NP and P decreased somewhat the content of "available" potassium (single extraction by a solution of ammonium acetate, as previously noted (1, 4). The fertilizers have virtually no effect on the content of total and hydrolyzable nitrogen.

The changes in proportion of nutrients in the soil as determined by analysis have a profound effect on the chemical composition of the plants (Table 5).

The phosphorous content of plants in the treatments involving this fertilizer was two to three times greater than in the other plants. The phosphorous intake (especially in the form of mineral phosphates—Table 6) when superphosphate alone was added was particularly high,



i.e., in the treatment where the negative influence of phosphorus is sharpest.

The corn plants in the different treatments differed little in nitrogen content, which is characteristic of this crop when sown by the square-hill method on rich chernozem soils. A somewhat greater nitrogen content following the application of phosphorous fertilizers was also characteristic.

The plants differed much more in potassium than in nitrogen content. The largest amount of

potassium was noted in the treatment with NK, as has been observed in experiments with other crops as well (3, 9). The addition of phosphorus after NK decreased the potassium content. After phosphorus alone the percentage of potassium in the plants was even higher than in the controls. This was evidently due to the fact that the plants in this treatment were stunted. Here too, judging by the ratio of P_2O_5 to K_2O in the plants, the plants suffered to some extent from a potassium deficiency (11). The dwarfing of plants as a result of excessive phosphorus is apparently caused by the heavy concentration of other ash

Table 3

Effect of continuous use of fertilizers on phosphorous content of the soil in mg of P_2O_5 per 100 g of soil from the plow layer. 1957 analysis.

Fertilizers	Total content	Soluble forms according to Chirikov				
		Single extraction		Total extraction		
		Acetic acid extract	Hydrochloric acid extract	Carbonic acid extract	Acetic acid extract	Hydrochloric acid extract
Background (1932)	142	—	18,6	2,5	—	—
Without fertilizers	143	14,7	16,3	1,2	24,1	32,3
P	173	28,3	33,7	21,6	50,4	67,4
NP	168	28,7	31,2	21,7	44,9	62,3
NK	148	17,1	17,3	1,7	24,6	34,5
PK	171	29,1	32,4	18,2	47,0	67,4
NPK	170	29,5	33,1	23,7	48,3	66,3
NPK (st)	159	18,1	19,4	1,9	—	38,6
Manure	164	17,1	18,4	1,6	26,2	36,7

Note: Comma represents decimal point.

CHANGES IN NUTRIENT REGIME

Table 4

Effect of continuous use of fertilizers on certain properties of soils. 1957 analysis.

Fertilizers	pH		Hydro-lytic acidity	Adsorbed bases		Humus, % (acc. to Tyurin)	Soil nitrogen		Soil K ₂ O	
	Water	Salt		Ca	Mg		Total	Hydro-lyzable	Total	Avail-able
			In meq per 100 g							
Background (1932) ^a	7,2	6,4	1,6	23,8	Not detd.	4,18	272	Not detd.	2115	9,8
Without fertil.	6,9	6,3	1,7	23,3	5,4	4,05	268	77	2000	8,8
P	6,7	5,9	2,4	22,3	6,3	3,99	262	83	1849	8,6
NP	6,0	5,1	5,2	20,5	6,0	4,14	268	84	1800	5,1
NK	6,7	5,5	3,5	20,7	4,4	3,98	266	79	1960	12,7
PK	6,9	5,9	1,9	21,6	6,0	3,97	259	77	—	11,9
NPK	6,2	5,2	5,0	19,4	5,4	4,07	271	82	1886	12,8
NPK (st)	6,8	5,7	3,2	21,5	5,0	4,11	Not detd.	—	—	9,7
Manure	7,6	6,8	0,8	24,0	5,2	4,21	279	79	1947	12,6

^aMean data for the experiment. No demonstrable differences in treatment of the experiment in 1932 were detected.

Note: Comma represents decimal point.

ments in the plants. For example, the calcium content of the controls was 0.982%, P, 1%; magnesium was 0.883% and 0.897%, respectively; ash was 5.16% and 9.24% (whole plants during the period of tasselling).

A substantial accumulation of soluble phosphates in the soil, therefore, results in super-saturation of the plants with phosphorus (7, 8) and a change in the proportion of nutrients. This, of course, leads to serious metabolic disturbances within the plants and markedly lowers their productivity. This is due to antagonism between absorption by the plants of phosphorus and potassium and the relative potassium (and possibly also magnesium) deficiency reduced physiological activity of potassium caused by excessive phosphorus, etc. All this,

in turn, apparently severely disturbs nitrogen exchange, intensifies the consumption of plastic substances in respiration, impairs the water regime of the plants, etc.

The hypothesis has also been advanced that the decreased productivity of plants following continuous use of phosphorous fertilizers may be due to the presence of fluorine in the soil. Our analysis (using Krylova's method with thorium nitrate) of corn plants showed some increase of fluorine in plots fertilized with superphosphate. It amounted to 54.8 mg in the plow layer of the control plot and 86.5 mg/kg after the addition of phosphorus; fluorine in the plants amounted to 3.10 and 4.22 mg/kg, respectively, of the dry mass.

Table 5

Content of nitrogen, phosphorus, and potassium in continuous cropping to corn as a percentage of absolutely dry substance

Fertilizers	Nitrogen				Phosphorus (P ₂ O ₅)						Potas. (K ₂ O)	
	Whole plant			Grain dur- ing har- vesting	Whole plant			Beginning of milk stage		Grain dur- ing har- vesting	Whole plant	
	6 leaves	8 leaves	During tassel- ing		6 leaves	8 leaves	During tassel- ing	leaves	stalks		8 leaves	During tassel- ing
Control	3,3	3,8	1,7	1,57	0,69	0,91	0,51	0,39	0,32	0,68	1,96	0,91
N	3,7	3,9	2,8	1,66	1,72	2,98	2,01	1,34	0,88	0,87	2,40	1,59
K	3,7	3,8	2,9	1,76	1,65	2,29	1,70	0,93	0,69	0,85	2,54	1,90
NK	3,5	3,9	2,2	1,80	0,82	0,97	0,58	0,42	0,35	0,67	4,06	2,69
K	3,7	4,0	2,3	1,72	1,52	1,97	1,52	0,84	0,72	0,84	3,72	1,96
PK	3,7	3,8	2,7	1,68	1,63	2,09	1,45	0,73	0,64	0,82	3,46	2,36
PK (st)	3,5	3,8	2,7	1,85	1,49	1,21	0,86	0,57	0,35	0,76	3,65	2,11
Manure	3,5	3,9	—	1,65	0,83	0,98	0,72	0,49	0,36	0,68	3,26	1,97

Note: Comma represents decimal point.

Table 6

Mineral phosphate content of plants in milligrams of P_2O_5 per 100 g of dry substance

Fertilizers	Time of analysis			
	6-leaf formation	8-leaf formation	Tasseling	Milk stage (leaves)
O	240	332	270	201
P	1130	2315	1652	1046
NK	258	424	289	210
NPK	904	1676	1194	602

It is hard to say just what effect this increase in fluorine has on plants. There are references in the literature to the fact that fluorine is required by corn and that an increase of it promotes the productivity of many plants (10). It is also stated that the addition of fluoride salts (about 60 kg/ha) to the soil has no particular effect on plants, that fluoride is sorbed in acid soil by the aluminosilicate complex, but is bound with Ca and Mg in alkaline soil (12).

We should like to point out in conclusion that the problem of excessive phosphorus in the soil is of practical as well as theoretical interest. It may well be that instances of "phosphatization" (5, 6) may be more widespread than is commonly supposed. For example, on the well fertilized fields of the aforementioned Mironov Experimental Station we observed a distinct decrease in the productivity of corn plants when superphosphate alone was added to the hills, whereas the effect of two or three chemicals applied together was good. In a permanent field experiment with fertilizers the Erastov Experimental Station of the All-Union Corn Research Institute (ordinary chernozem soil) began to add superphosphate to the hills and rows of half the area of all the plots in the second rotation of a 9-field crop rotation (1957, 1958). It has been discovered on previously non-fertilized or lightly fertilized plots that the hill method of using superphosphate increases the yield of corn, that on moderately fertilized plots it has no effect, and that on (relatively) heavily fertilized plots it reduces the yield.

Owing to the different responses of crops to phosphorus, it is desirable that soil studies in regions where fertilizers are heavily used should single out the fields overly fertilized with phosphates so as to provide the basis for sound redistribution of individual crops and corresponding changes in the fertilizer routine. Planning agencies should work out another system of allocating fertilizers with due regard in order to increase the size of deliveries of nitrogen and potassium as compared with phosphorus in regions that have long made intensive use of fertilizers.

Received April 13, 1959

BIBLIOGRAPHY

1. KUDZIN, YU.K. 1936. Effect of different

methods of fertilizing beet crop rotations on soil processes, yield, and quality of sugar beet. *Sbornik: Udobreniya v sevo-oborote*, No. 2.

2. KUDZIN, YU.K. 1946. Proportion of mineral fertilizers after manure in the fertilization system of a grain-beet crop rotation. *Byulleten' Sumskoy sel'skokhozyaystvennoye opytnoy stantsii*, No. 3.
3. KUDZIN, YU.K. 1955. Effect of the proportion of nutrients in fertilizers on the yield of grain crops following prolonged use of fertilizers in crop rotations. *Sb.: O pitanii rasteniy. Sel'khozhigiz*.
4. PYATENKO, A.I. 1928. Potassium exhaustion of chernozem. *Trudy Mironovskoy opytnoy stantsii*. No. 3.
5. SOKOLOV, A.V. 1957. Effect and residual-effect of phosphorous fertilizers in experiments lasting many years. *Dokl. Izd. MSKh SSSR*.
6. SOKOLOV, A.V. 1958. Content of available phosphates in soil and their accumulation following the use of phosphorus fertilizers. *Pochvovedeniye*, No. 2.
7. TURCHIN, F.V. 1936. Nature of fertilizer action. *Sel'khozhigiz*.
8. TURCHIN, F.V. 1937. Significance of the form of nitrogen fertilizers for ash nutrition of plants. *Sb.: Novoye v udobrenii*, No. 2.
9. SHUSTOVA, YE.N. 1955. Some peculiarities in sugar beet nutrition after prolonged use of fertilizers in crop rotations. *Ibid*.
10. KHALIZEV, A.A. 1933. Stimulating fertilizers. *Sprav. po udobreniyam. Goskhimizdat*.
11. DELL, W. and P.L. ARENS. 1957. Inefficacité du phosphate naturel pour le palmier a huile sur certains soils de Sumatra. *Oléagineux*, 12:11.
12. MACINTIRE, WALTER H. 1957. Fate of air-borne fluorides and attendant effects upon soil reaction and fertility. *J. Assoc. Offic. Agric. Chemists*, 40:No. 3.

DISCUSSION

SOIL CLASSIFICATION IN THE AGRICULTURAL DISTRICTS OF UZBEKISTAN

V. KIMBERG, M. I. KOCHUBEY, and S. P. SUCHKOV, All-Union Research Institute for Cotton Growing

Soil classification problems are now becoming of particular importance in relation to the setting up of a soil and agricultural chemical service, soil conservation and the compilation of large-scale soil maps in a number of Central Asian republics. When the detailed soil studies are complete it will be even more essential to summarize the materials at inter-republic and ultimately at an All-Union level. A basic outline of soil classification should be therefore worked out and discussed at the present time.

The present article is merely an exposition of the main principles on which the classification scheme, used in compiling soils maps of the kolkhozes and sovkhoses of Uzbekistan, has been based¹ and does not claim to be an exhaustive examination of the theory.

The territory of Uzbekistan is subdivided into two parts (a latitudinal zone and an altitudinal belt) in relation to the conditions of soil

formation and the nature of the soil. Automorphic, transitional and hydromorphic soils are distinguished in each part.

Hydromorphic soils are divided both by genetic type and also in relation to the origin of the soil-forming parent materials and ground waters and to the ground-water regime. This leads to subdivision into sod alluvial, alluvial and water-logged.

Floodplain-alluvial soils are hydromorphic soils. Flooding, which is an important factor in the moisture regime of these soils, is responsible for their generally slight salinization, marked textural stratification and certain other features.

The alluvial soils are soils of the low river terraces, with a fluctuating ground-water table controlled by the water regime of the river. The soils are highly stratified.

Water-logged ("sazovyye") soils are hydromorphic soils developed on foothill slopes and upper river terraces, where the flow of ground waters from the mountains tapers off at or near the surface owing to an increase of fine-textured deposits and a decrease in the slope. As a result of the distance of the source, the ground-water table is very stable under these conditions.

The article is based on classification principles used in soil studies and developed in a number of papers (1-5).

DIVISION OF SOILS BY GENETIC GROUP

SOILS OF THE LATITUDINAL PLAIN ZONES. DESERT ZONE

Automorphic

	Index
grey-brown	GB
newly irrigated grey-brown	ni GB
fert sandy	DS
typ soils	
takyr	T
takyr-like	Tl
newly irrigated takyr-like	ni Tl
old irrigated takyr-like	oi Tl
residual solonchaks	rS

Transitional

meadow-desert	MD
meadow-takyr types	MTl
newly irrigated meadow-takyr types	ni MTl
old irrigated meadow-takyr types	oi MTl
takyr-like meadow	Tl-M
newly irrigated takyr-like meadow	ni Tl-M
Old irrigated takyr-like meadow	oi Tl-M

Hydromorphic

Meadow	M ^f
floodplain alluvial	M ^f _{1a}
alluvial	M ^f _a
newly irrigated alluvial	ni M ^f _a
old irrigated alluvial	oi M ^f _a
water-logged ("sazovyye")	M ^f _s
newly irrigated water-logged	ni M ^f _s
old irrigated water-logged	oi M ^f _s
Bog-meadow	B-M ^f
floodplain alluvial	B-M ^f _{1a}
alluvial	B-M ^f _a
newly irrigated alluvial	ni B-M ^f _a
old irrigated alluvial	oi B-M ^f _a
water-logged ("sazovyye")	B-M ^f _s
newly irrigated water-logged	ni B-M ^f _s
old irrigated water-logged	oi B-M ^f _s
Bog soils	B ^f
floodplain alluvial	B ^f _{1-a}
alluvial	B ^f _a
irrigated alluvial	i B ^f _a
water-logged ("sazovyye")	B ^f _s
irrigated water-logged	i B ^f _s
Solonchaks	
typical solonchaks	Sk
alluvial	Ska
water-logged ("sazovyye")	Sks
meadow solonchaks	Sk _m
alluvial	Sk _{ma}
water-logged ("sazovyye")	Sk _{ms}
bog solonchaks	Sk _b
alluvial	Sk _{ba}
water-logged ("sazovyye")	Sk _{bs}

ALTITUDE BELT SOILS. SIEROZEM BELT

Automorphic

Sierozems	
light sierozems	Sl
newly irrigated light	ni Sl
old irrigated light	oi Sl
typical sierozems	S
newly irrigated typical	ni S
old irrigated typical	oi S
dark sierozems	S _d
newly irrigated dark	ni S _d

SOIL CLASSIFICATION IN UZBEKISTAN

Index

old irrigated dark	oi Sd
Transitional	
meadow-sierozems	MS
newly irrigated meadow-sierozems	ni MS
old irrigated meadow-sierozems	oi MS
sierozem-meadow	SM
newly irrigated sierozem-meadow	ni SM
old irrigated sierozem-meadow	oi SM
Hydromorphic	
meadow	M ^S
floodplain alluvial	M _{f-a} ^S
alluvial	M _a ^S
newly irrigated alluvial	ni M _a ^S
old irrigated alluvial	oi M _a ^S
water-logged ("sazovyie")	M _s ^S
newly irrigated water-logged	ni M _s ^S
old irrigated water-logged	oi M _s ^S
meadow-meadow	B-M ^S
floodplain alluvial	B-M _{f-a} ^S
alluvial	B-M _a ^S
newly irrigated alluvial	ni B-M _a ^S
old irrigated alluvial	oi B-M _a ^S
water-logged ("sazovyie")	B-M _s ^S
newly irrigated water-logged	ni B-M _s ^S
old irrigated water-logged	oi B-M _s ^S
meadow soils	B ^S
floodplain alluvial	B _{f-a} ^S
alluvial	B _a ^S
irrigated alluvial	i B _a ^S
water-logged ("sazovyie")	B _s ^S
irrigated water-logged	i B _s ^S
solonchaks	Sk
typical solonchaks	Ska
alluvial	Skas
water-logged ("sazovyie")	Skms
meadow solonchaks	Skma
alluvial	Skmb
water-logged ("sazovyie")	Skmba
bog solonchaks	Skbs
alluvial	Skbsa
water-logged ("sazovyie")	Skbsb

This list does not contain all the soils, but only those that are most widespread and that have been studied to some degree. Some soil types (e.g., sierozems) are therefore shown in greater detail than others (e.g., meadow-sierozems). This is because dark, typical and at sierozems are widespread and well known, whereas meadow-sierozems for example, in the belt of dark sierozems (which should be called "meadow-sierozem soils of the dark sierozem belt") have not yet been described, although they are theoretically possible. Meadow-sierozem soils are therefore given without subdivision by belts (light, typical and dark

sierozems), in the same way as meadow, bog meadow and bog soils, for which no differences by belts have as yet been established.

Three categories of irrigated soil are distinguished in the list. Newly irrigated soils are soils in which only the upper part of the profile (e.g., the sod-forming humus horizon of sierozems or meadow soils) has been altered by plowing and irrigation, while the lower genetic horizons (carbonate and gypsum) are retained.

The second category is old irrigated soil in

which the profile has been altered to a great depth by continuous irrigation: carbonates and gypsum have been dissolved and leached out and the soil is deeply colored by humus. In many cases the thickness of an old irrigated soil is the same as that of the "agricultural-irrigational" horizon. In some districts however, especially where the suspension content of the irrigation water is slight and earthy fertilizers are not used, there is no "agricultural-irrigational" horizon in old irrigated soils and their thickness is established from traces of the activity of biological agents (root systems, land animals, humus coloration).

The third category is old irrigated soil which is divided into: thin, with a humus colored horizon of up to 30 cm (plowed layer); medium — up to 70 cm (cotton root layer) and thick — greater than 70 cm.

Owing the conditions under which they have developed, some soils do not show any features associated with the duration of irrigation. These conditions are continual exceptional wetting from ground waters near the surface, which interferes with the activity of biological agents and causes a high degree of gleying in the profile that masks the humus coloration. These soils (e.g., irrigated bog soils) are classified as irrigated, without further subdivision.

Soils which by the conditions of their development are intermediate between two soil groups are classified as transitional in both the desert zone and the sierozem belt. These are meadow-sierozem and sierozem-meadow soils in the sierozem belt and meadow-takyr and takyr-meadow soils in the desert zone. The first group combine the features of meadow soils and sierozems and differ in the extent to which one type predominates or in the direction of the process. Meadow-sierozems are soils on territories that are drying out (the ground-water level is falling) and are developing from meadow soils to sierozems. The opposite conditions hold for sierozem-meadow soils — ground waters are rising, owing to irrigation for example, and the sierozems are acquiring the features of meadow soils.

Division of Soils According to Salinization

According to the position of the salt horizon (the horizon in which the content of water-soluble salts is not less than 0.3%) irrigated soils are divided into: non-saline, in which there is no salt horizon for 2 m; deep saline, in which the salt content is higher than 0.3% in the layer from 100 to 200 cm; saline, higher than 0.3% in the layer 0-100 cm.

Non-irrigated soils (virgin, abandoned and long fallow) are divided into: non-saline, in which there is no salt horizon for 2 m; deep saline, in which the salt content is higher than 0.3% in the layer from 100 to 200 cm; solonchakized, higher than 0.3 in the layer from 30 to 100 cm; solonchak-like, higher than 0.3 in the upper genetic horizon or in the 0-30 cm layer.

All soils (irrigated and non-irrigated) are

classified as follows by the degree of salinization:^a

Table 1

Soils	Density of residue	Chlorine
	In percentages	
Non-saline	<0,3	<0,01
Slightly saline	0,3—1,0	<0,01
"	<0,3	0,01—0,04
Moderately saline	1,0—2,0	0,01—0,04
"	0,3—1,0	0,04—0,1
Strongly saline	2,0—3,0	0,04—0,1
"	1,0—2,0	0,1—0,3
Solonchaks	>3,0	>0,3

^aCombined scale — chlorine according to Fedorov's method, density of residue according to the SoyuzNIKHI method.

Note: Comma represents decimal point.

Saline soils are further subdivided by Lebedev's outline (see Table 2) of salt composition (types of salinization).

Division of Soils by Texture

The structure and texture of a 2 m layer is taken into consideration in soil mapping and the following 3 sectors are considered independently:

the 0 to 30-40 cm layer, the upper meter (0-100 cm) and the second meter (100-200 cm); the 0 to 30-40 cm layer is the plowed layer of a cultivated or will be cultivated soil; the upper meter is the layer in which calculations are made for hydrological regionalization.

The movements of water and salts that are of importance to agriculture are determined by the texture of the second with the top meter.

Soils and soil materials of uniform texture are subdivided into the following categories:

1. Fine-textured — clays and fine clay loams; medium-textured — medium clay loams;
3. Coarse-textured — coarse clay loams and sandy loams; 4. sands.

The upper 0-30 cm of stratified soils is equated to uniform soils (by averaging) and classified by texture as shown previously.

The 0-100 and 100-200 cm layers of stratified soils and soil materials are divided into the following groups by texture:

1. A stratified complex of clays, fine and medium clay loams;
2. Clays, fine and medium clay loams with subsidiary stratifications of coarse clay loams, sandy loams and sands;

SOIL CLASSIFICATION IN UZBEKISTAN

Table 2

Type of saline soils (after Lebedev)

By anions				By cations			
$\frac{Cl}{SO_4}$	$\frac{SO_4}{Cl}$	$\frac{HCO_3}{SO_4+Cl}$	Type of salinization	$\frac{Na+K}{Ca+Mg}$	$\frac{Ca+Mg}{Na+K}$	$\frac{Mg}{Ca}$	Type of salinization
>2 $1-2$	$<0,5$ $0,5-1$	—	Chloride Sulfate-chloride	>2 $1-2$	$<0,5$ $0,5-1$	— >1	Sodium Magnesium-sodium
$1,2-1$	$1-5$	—	Chloride-sulfate	$1-2$	$0,5-1$	<1	Calcium-sodium
$<0,2$	>5	—	Sulfate	<1	>1	>1	Calcium-magnesium
$<0,2$	>5	>1	Carbonate-sulfate	<1	>1	<1	Magnesium-calcium

Note: Comma represents decimal point.

3. Coarse clay loams, sandy loams and sands with subsidiary stratifications of clays and fine medium clay loams;

4. A stratified complex of coarse clay loams, sandy loams and sands.

Texture is determined from Kachinskiy's classification for carbonate soils.

Division of Soils by the Depth of the Ground-Water Table

Soils are classified by the depth of the ground-water table, allowance being made for the genetic nature of the soils and for certain initial data concerning hydrological regionalization and the planning of meliorative measures. The following categories are proposed: 0-0.5 m; 0.5-1.0 m; 1.0-2.0 m; 2.0-3.0 m; 3.0-5.0 m; 5.0-10.0 m; >10.0 m (from the high-level).

The mineralization of ground waters is determined from Priklonskiy's classification.

Table 3

Category	Density of residue, g/l
Fresh	0-1
Slightly mineralized	1-3
Moderately mineralized	3-10
Strongly mineralized	10-50
Brines	>50

Division of Soils from the Depth of the Pebble Layer

When classifying soils from the depth of the gravel layer, allowance is made for the existing conditions of cultivating implements, water-holding capacity of the soils when

planning irrigation and the use of chemical and organic fertilizers; the following categories are distinguished: 0-30 cm; 30-50 cm; 50-100 cm; 100-200 cm; >200 cm.

Division of Soils by the Degree of Erosion

The soils of the sierozem belt only are subdivided according to the degree of erodibility into: non-eroded, slightly eroded, heavily eroded, and deposition.

Non-eroded soils are plain soils with a normally developed profile.

Slightly eroded soils are on gentle slopes and the upper part of steep slopes, in which the A horizon has been partly eroded, so that the humus horizon is reduced in thickness and the carbonate horizon lies closer to the surface.

Heavily eroded soils are on steep slopes, in which the A or A + B₁ horizon has been eroded and the carbonates lie at or near the surface.

Deposition of soils are those in depressions and on the tapering lower parts of slopes, in which the humus horizon has been extended by deposition.

The presence and depth of rills, the growth and development of plants and other factors are additional features from which the degree of erodibility or deposition can be assessed.

Received January 4, 1960

BIBLIOGRAPHY

1. GORBUNOV, B. V., N. V. KIMBERG, and S. A. SHUVALOV. 1941. Experimental soil classification of Uzbekistan. Tr. Uzb. filiala Akad. Nauk SSSR, Ser. 10: Pochvovedeniye, No. 1, Tashkent.

2. 1949. The soils of Uzbekistan. Vol. 1.
Izd. Akad. Nauk UzSSR. Tashkent.
3. 1957. The soils of Uzbekistan, Vol. 2,
Izd. Akad. Nauk UzSSR. Tashkent.
4. 1957. The soils of the cotton districts of
Central Asia. In: Khlopchatnik. Vol. 2,
Izd. Akad. Nauk UzSSR. Tashkent.
5. SUCHKOV, S. P. 1950. Soils of the cotton
districts of Uzbekistan. Izd. SoyuzNIKHL.
Tashkent.

METHODS

AGRICULTURAL-CHEMICAL CHARACTERISTICS OF THE TEREK RIVER DEPOSITS

E. N. BUD'KO, Southern Scientific Research Institute for Hydrotechnical Engineering and Melioration

The importance to soil-forming processes and soil fertility of the suspended deposits that reach irrigated areas with the irrigation water has often been noted in the literature (1-6). The present article gives chemical data on the deposits of the Terek River. We studied this question in connection with the work of the VkhNIIGiM on the reconstruction of irrigation systems in the Terek delta (Kizlyar district) and related it to the use of sedimentation tanks to prevent the silting of canals.

Definite features were observed in the distribution of the suspended material that passed through the sedimentation tank. Particles >0.01 mm in diameter, which make up more than 50% of the suspension in the flow and which cause silting in canals, settled in the sedimentation tank, whereas particles <0.01 mm in diameter were carried out into the canal.

The annual total of suspended material in the Terek River from 1925 to 1936 fluctuated within the range 12.4-39.3 million metric tons (Khir-Adzhi Yurt station). The annual discharge of particles suspended in water for 1933-1938 was 267 kg/sec. Mean monthly discharge fluctuated within the range 5.7-28.12 kg/sec. Mean water turbidity was 8.24%, the highest monthly figure being 4.1%-14.2%. Flood deposits ranged from 9.61 to 15.96 kg/ha.

The following deposits were studied: Borozdino sedimentation tank - samples 1, 5 and 7;

Kargalinskaya sluice - sample 2; sedimentation tank of the Delta canal - sample 3; an experimental sedimentation tank on the Talovka River - samples 4 and 6; several samples from the Borozdino sedimentation tank (293, 294, 299, 300, 11, 12, 13, 14) and the Kargalinskaya sluice (sample 15).

The particle-size composition of the deposits varies in relation to the rate of flow, turbidity, time and place at which the sample was taken. Tables 1 and 2 show the variations in a sedimentation tank, a canal and other sites.

The composition of the deposits varies in the main from silty-clay or silty - clay loam to silty-sandy: fine or coarse silt particles predominate and the clay content is low. Determination of the colloid groups showed that the colloid fractions amounted to 35.6%-37.4% in the fine-textured deposits, and 2.8%-5.7% in coarse-textured deposits. A large part of the colloids are from group I, only a small amount of group II (1%-3%) being present.

Humus content varies in relation to the texture in the range 0.07%-2.38% and is normally directly related to an increase in the quantity of the clay fraction: the average content in deposits with similar amounts of clay particles (78%-86%) was 2.05% (Tables 1 and 5).

There is a similar connection to be observed between the texture and the content of total and

Table 1

Content in deposits of particle diameters <0.01 mm and humus as %, and of readily available N and P_2O_5 in mg/kg

Indices	Borozdino sedimentation tank				4 km above the Davydov canal	Davydov canal		
	Samples					kilometers		
	293	294	299	300		25	28	30
Particle diam. $<0,01$ mm	1,2	12,1	82,2	88,2	6,5	22,5	23,2	38,9
Humus	0,37	1,80	1,99	2,38	0,45	1,27	2,03	2,12
P_2O_5	37,6	40,0	52,0	58,4	—	—	—	—
N	—	—	—	—	50,1	70,9	118,2	158,44

Note: Comma represents decimal point.

Table 2
Particle-size analysis and chemical composition of suspended deposits

Sample Number	Sample taken from	Total nitrogen, %	Total P_{2O_5} , %	K, mg/100 g (Peyve's method)	CO_2 in %	Content of the fractions as percentages						Exchange capacity, meq per 100 g	Colloid content, %			
						>0.25	Particle diameters, mm						Total	Groups		
							0.025-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.01					
1	Borzdino sedimentation tank	0,18	0,17	32,0	6,66	None	8,2	14,8	51,8	16,3	8,90	77,0	16,8	37,38	36,08	2,30
2	Kargalinskaya sluice	0,14	0,19	—	7,64	"	2,6	19,4	4,3	48,9	24,8	78,0	17,6	30,05	27,25	2,70
3	Delta canal	0,18	0,15	—	5,56	"	0,4	27,6	20,9	36,5	14,6	72,0	14,8	38,78	34,93	0,85
4	Experimental sedimentation tank on Talovka River	0,17	0,16	—	—	"	21,8	20,9	16,8	26,0	14,5	57,3	12,4	19,20	16,22	2,98
5	Borzdino sedimentation tank	0,14	0,15	—	—	"	11,2	58,3	11,5	15,9	3,1	30,5	12,5	—	—	—
6	Experimental sedimentation tank on Talovka River	0,9	0,14	15,0	4,70	"	47,7	25,9	7,6	13,9	4,9	26,4	—	5,72	4,20	1,52
7	Borzdino sedimentation tank	0,04	0,12	5,32	3,47	6,1	80,9	9,0	1,6	0,3	2,1	4,0	4,5	2,05	1,22	1,63

Note: Comma represents decimal point.

readily available forms of N and P_2O_5 , which are directly related to increase in the quantity of physical clay.

There is a large amount of CO_2 , ranging from 3.47% in a sandy to 7.14% in a silty-clay deposit. The content of water-soluble substances in the various deposits is fairly uniform and varies between 0.21% and 0.07%. Bicarbonate and sulfate Ca^{++} and Mg^{++} predominate in a water extract. There is a numerical relationship between texture and the content of water-soluble compounds in the clay and clay loam deposits of the Borzdino sedimentation tank (Table 3).

Both the carbonate-sulfate nature of the salinization of the deposits and their high carbonate level are favorable to the saline soils of the Terek delta, bearing in mind the possibility that solonetization may develop when they are irrigated.

Exchange capacity is low, fluctuating between 13.8 and 17.6 meq/100 g in silt-clay deposits, owing to the large content of silty particles and the insignificant amount of the clay fraction. In a silt-loam deposit the exchange capacity was 12.4 meq/100 g (Table 2).

Total chemical analysis show that the SiO_2 and MgO content increases and the SO_3 and CaO content decreases as the clay fraction in the deposits increases (Table 4).

It follows from these data that the annual addition of 9.61-15.96 kg/ha of Terek deposits with irrigation water to the fields enriches the soil with 6.7-380 g/ha of humus, 3.8-28.7 g/ha of N, 11.5-30.2 g/ha of P_2O_5 , 3.0-0.85 g/ha of K and 326-1212 g/ha of CO_2 in the form of Ca and Mg carbonates, and that there is a definite relationship between the texture of the deposits and the nutrient content: fine deposits consisting mainly of particle diameters <0.01 mm that pass through the sedimentation tank to the irrigated areas are richest in nutrients.

Pot experiments in 1941 and 1946 also revealed the importance of deposits of different texture in relation to agricultural-chemical properties and plant development.

In the 1941 experiments we used deposits from the Borzdino sedimentation tank (samples 1, 5 and 7): silty clay with a humus content of 2.16%; coarse-silt clay loam with 2.0% humus and fine sand with 0.07% humus. The samples are described in Table 2. The experiments with millet as a crop were conducted at 60% of saturation moisture capacity and were replicated twice.

The indices for the height of the plants and for the weight of the dry mass and the grains (Fig. 1) show that the clay deposit was of greater value as a fertilizer than the clay loam and sand.

The 1946 pot experiments were conducted with five deposits, four of which (samples 11, 12, 13 and 14) were taken from the Borzdino sedimentation tank and the fifth from the Kargalinskaya sluice (sample 15): texturally these deposits were: fine silt clay; coarse silt-fine clay loam; coarse silt-sandy loam and coarse silt-sand. Samples 11 and 15 and 12 and 13 were similar in texture. Saturation moisture capacity,

TEREK RIVER DEPOSITS

Table 3

Analysis of water extracts of the deposits

Sample No.	Sample taken from	Cl ⁻	SO ₄ ⁻⁻	HCO ₃ ⁻	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	Total of ions
1	Borozdino sediment. tank	0,021 ^a 9,7	0,084 27,9	0,047 12,4	0,40 32,0	0,008 11,0	0,010 7,0	0,21
2	Kargalinskaya sluice	0,005 7,7	0,044 17,0	0,043 25,3	0,022 38,0	0,007 9,4	0,002 2,6	0,12
3	Delta canal	0,005 7,7	0,026 14,1	0,048 28,2	0,024 33,4	0,002 15,6	0,0001 1,0	0,10
4	Experimental sediment. tank on Talovka River	0,007 4,9	0,018 18,2	0,045 26,9	0,018 39,6	0,006 9,4	0,0001 1,0	0,09
6	The same	0,006 3,9	0,018 26,0	0,034 20,1	0,016 30,8	0,002 17,0	0,002 2,2	0,08
7	Borozdino sediment. tank	0,007 8,5	0,023 18,8	0,025 22,7	0,017 33,0	0,004 14,8	0,002 2,2	0,08

^aIn grams in the numerator and in % of meq per 100 g of dry soil in the denominator.
Note: Comma represents decimal point.

Table 4

Total chemical composition of deposits, %

Sample No.	Sample taken from	SiO ₂	SO ₂	MnO	CaO	MgO	Particle diameters <0.01mm
1	Borozdino sedimentation tank	51,03	1,99	0,17	8,75	1,65	77,0
2	Kargalinskaya sluice	52,61	1,37	0,14	8,63	1,38	78,0
4	Exper. sediment. tank on Talovka	57,93	1,85	0,16	6,81	3,02	57,3
6	The same	63,12	1,23	0,06	4,94	1,50	26,4
7	Borozdino sedimentation tank	66,67	1,02	0,17	6,16	3,39	4,00

Note: Comma represents decimal point.

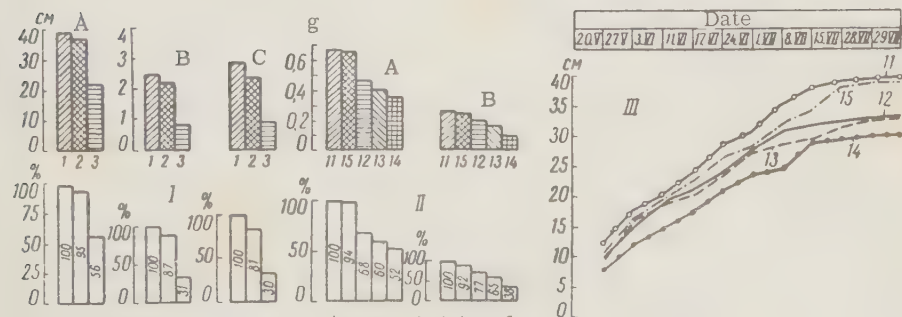


Fig. 1. - Pot experiments in 1941. A - height of plants; cm; B - weight of dry mass, g; C - weight of grains, g. 1 - clay; 2 - clay loam; 3 - sand.

Fig. II. - Pot experiments in 1956. A - weight of dry mass; B - weight of grains. 11 - clay; 12-13 - sandy loam; 14 - sand; 15 - clay loam.

Fig. III. - Pot experiments in 1946. Height of plants, cm. 11 - clay; 12-13 sandy loam; 14 - sand; 15 - clay loam.

Table 5

Particle-size analysis and certain chemical and moisture properties of deposits

Sample Number	Sample taken from	Content of the fractions, %							Humus content, %	Exchange capacity, 100 meq per g of soil	Maximum hygroscopicity	Satur. moist. capacity
		Particle diameters, mm									As %	
		1,00— —0,25	0,25— —0,05	0,05— —0,01	0,01— —0,005	0,005— —0,001	<0,001	<0,01				
11	Borozdino sedi- ment. tank	0,1	6,3	39,3	15,2	32,3	6,8	54,3	2,36	12,68	2,73	36,0
15	Kargalinskaya sluice	0,1	1,6	49,3	14,4	29,9	4,7	49,0	2,18	12,36	2,73	35,0
12	Borozdino sedi- mentation tank	0,8	39,0	44,0	5,2	8,3	2,7	16,2	—	—	0,62	28,0
13	The same	0,1	51,4	36,5	4,2	5,2	2,6	12,0	1,27	9,05	0,61	28,0
14	The same	0,1	47,2	45,7	1,5	1,6	3,9	7,0	—	0,57	0,57	17,0

Note: Comma represents decimal point.

exchange capacity, maximum hygroscopicity and humus content corresponded with the texture (Table 5). The experiments, which were with barley at 60% of saturation moisture capacity, were replicated three times.

The experimental results are shown in Figures 2 and 3. As with the results of the 1941 experiments they reflect the texture and properties of the deposits with the height of the plants and the dry mass total and weight of the grains. Plant development is improved and the weight of the dry mass and grains increased when the texture is finer, i.e., when there is a high content of nutrients in the deposit.

Conclusions

1. The suspended deposits of the Terek enrich the irrigated fields with the nutrients essential to plant development - humus, N, P_2O_5 and K.

2. There is a definite relationship between the texture of the deposits and the amount of nutrients in them. Deposits consisting of fine fractions are the most valuable.

Received May 8, 1959

BIBLIOGRAPHY

1. GORBUNOV, N.I. 1958. The mineralogical and chemical composition of the clay fraction in certain soils and soil-forming parent materials and in the suspensions of rivers in the Kura-Araks lowland. Tr. pochv. in-ta im. V.V. Dokuchayeva Akad. Nauk SSSR. Vol. 53.
2. KOVDA, V.A. 1954. Fertility increase and melioration of soils in irrigated districts. Pochvovedeniye, No. 7.
3. MOLODTSOV, A. 1958. Description of the irrigation deposits of the Samarkand oasis. Pochvovedeniye, No. 2.
4. ROZANOV, A.N. 1948. Some of the features of irrigation deposits on cultivated soil. Pochvovedeniye, No. 12.
5. ROZANOV, A.N. 1951. The sierozems of Central Asia. Izd. Akad. Nauk SSSR.
6. ROZANOV, A.N. 1959. The importance of irrigation deposits in the genesis, fertility and melioration of irrigated soils. Pochvovedeniye, No. 2.
7. SHEYNKIN, G.YU. 1957. Operational methods of dealing with deposits in irrigation systems using sedimentation tanks of lake type. Soil melioration in the valley of the Vakhsh. Tr. Akad. Nauk TadzhSSR. Vol. 78.

SOME FEATURES OF SOD ARCTIC SOILS ON BOLSHEVIK ISLAND

S. MIKHAYLOV, Arctic and Antarctic Research Institute, Leningrad

In contemporary soil classification a separate group of sod arctic soils has been tentatively distinguished (4). These are soils of circum-arctic distribution on the islands and shores of the Arctic Ocean. Although they are mentioned in a few works, no systematic study has yet been made. The soils of Franz Josef Land were studied by Ivanov (3) and those of the islands of Wrangel and Wrangel by Gorodkov (1, 2). Arctic soils remain completely undescribed throughout the greater part of their territory. This article is devoted to the soil features of the southern part of Bolshevik island (Severnaya Zemlya).¹

The climate on Bolshevik is one of extreme severity. Mean daily temperatures are only positive for 1.5-2 months in the year and frosts are possible at any time. The mean monthly temperature in July and August is not above 2.5°. Summer precipitation does not exceed 50 mm.

The snow thaws intensively and the melt waters run over the surface of the unthawed soil without basically wetting it. In summer the soil receives moisture from precipitation, the thawing of ground ice and condensation. Owing to

night-and-day insolation there is intensive evaporation from the surface of the soil when the wind is strong and transpiration by plants is enhanced. The amount of moisture in the soil probably decreases in July and August, thus creating conditions for aerobic microbiological processes, which are also assisted by the fissuring and high porosity of arctic soils.

The vegetation on Bolshevik does not form a continuous cover, but grows in the isolated beds around frost fissures.

We have classified the soils of Bolshevik as low humus sod arctic soils and we shall give a morphological description of them.

Profile 147. Bolshevik, coast of Solnechnaya Bay. Ten meter marine terrace, 25%-30% covered by moss and grass vegetation;

A₁' 0-12 cm. Cinnamon-brown to brown, clay loam, fine nut-like, compacted, moist, plenty of roots. Gradual transition.

A₁'' 12-30 cm. Cinnamon-brown to brown, lighter than the foregoing, clay loam, slightly sandy, non-stable fine nut-like, compacted, moist, plenty of roots. Transition on the thawing boundary.

C 30-35 cm. Straw-grey, sandy loam, compact, frozen.

These soils were studied in 1956-57. The analyses were made by S. N. Sheyko in the Moscow State University.

Table 1

Physicochemical characteristics of low humus sod arctic soils

Profile No.	Depth, cm	Humus, % (Tyurin method)	pH		Adsorbed cations					Adsorption capacity, meq	Fe, mg/100 g (Tamm's method)
			Water	Saline	In meq		As a % of the total				
					Ca ⁺⁺	Mg ⁺⁺	Total	Ca ⁺⁺	Mg ⁺⁺		
47	0—10	2,40	6,4	5,7	9,00	3,60	12,60	73,8	26,2	12,62	743
	15—25	1,95	6,4	5,8	8,16	3,36	11,52	70,5	29,5	11,53	705
	30—35	0,36	6,7	5,8	4,32	2,28	6,60	68,2	31,9	6,60	550
32	0—4	2,30	6,5	5,8	6,24	3,50	9,74	66,6	33,4	9,25	714
	20—30	0,51	6,7	5,8	4,20	3,72	7,92	53,1	46,9	7,92	846
	40—45	0,41	6,8	5,8	4,32	3,00	7,32	62,2	37,8	7,32	833

Note: Comma represents decimal point.

Table 2

Fractional composition of organic matter of low humus sod arctic soils, as % of total humus

Profile No.	Depth, cm	Humic acids				Fulvic acids						C h. C f.
		Ia	I	II	Total	Ia	I	II	III	IV	Total	
147	0-10	5,42	19,58	14,70	39,70	6,80	15,74	13,85	4,09	19,32	59,80	0,6
182	0-4	11,63	23,92	9,66	45,21	3,09	13,72	11,98	1,40	24,60	54,79	0,7

Note: Comma represents decimal point.

Table 1 shows that the upper horizon of the soils is cinnamon-brown to brown and contains more than 2% of humus. The humus profile is extended. There is also almost 2% of organic matter at a depth of 20 cm. The reaction of these soils is weakly acid. The adsorption capacity is 9-12 meq in the humus and 4-5 meq in the lower horizons.

The exchangeable complex of the soil is almost fully saturated with calcium and magnesium; the degree of saturation reaching 99%. The content of adsorbed hydrogen is not more than 1% of the total adsorbed cations. The high saturation and neutral reaction of the soils are associated with the fact that the alkali-earth cations liberated by weathering remain in situ and enter the exchangeable complex of the soil. The distribution of available iron throughout the profile agrees with the altered content of the colloid fraction and shows that iron migrates to the upper horizons of the soil when it is frozen, as

Tyutyunov (7) has pointed out.

The group composition of the organic matter was analyzed by Tyurin's method (Table 2). The humic and fulvic acids were separated into the following groups:

a) humic and fulvic acids of group Ia in a free state. Humic acids and fulvic acids of group I in the form of fulvates and humates of calcium and partly bonded with sesquioxides. b) humic acids and fulvic acids of group II that are polymer complexes, or stably bonded with the stable hydrates of sesquioxides. Groups III and IV, associated with the clay fraction, were also distinguished in the fulvic acids.

There are more fulvic than humic acids in these soils. The C ratio of the humic to the fulvic acids is 0.6-0.7. Fulvic acids associated with clay particles are of major importance in these soils. A large part is also played by cal-

Table 3

Particle-size analysis of sod arctic soils, %

Profile No.	Depth, cm	Diameter of particles, mm					
		1-0,25	0,25-0,05	0,05-0,01	0,01-0,005	0,005-0,001	<0,001
147	0-10	4,28	48,14	8,56	1,52	6,24	28,60
	15-25	1,10	52,14	6,92	1,68	5,92	28,16
	30-35	2,78	61,03	5,76	0,98	3,88	21,12
182	0-4	3,02	62,13	10,40	3,53	4,24	13,36
	20-30	2,78	53,08	13,24	7,08	4,60	16,12
	40-45	1,70	55,13	13,14	6,99	4,64	15,40

Note: Comma represents decimal point.

Table 4

Fractional composition of the organic matter of humified sod arctic soil, as % of the total humus

Profile No.	Depth, cm	Humic acids				Fulvic acids						C h. C f.
		Ia	I	II	Total	Ia	I	II	III	IV	Total	
112	5-15	19,30	25,03	2,90	47,23	2,10	7,20	31,50	1,50	7,50	49,80	0,9
	20-30	11,82	26,46	4,37	42,65	0,10	11,33	43,10	2,72	0,20	57,35	0,7

Note: Comma represents decimal point.

SOD ARCTIC SOILS

Table 5

Physicochemical features of humified sod arctic soil

Profile No.	Depth, cm	Humus % (Tyurin method)	pH		Adsorbed cations					Adsorption capacity, meq	Fe, mg, 100 g (Tamm's Method)
			Water	Saline	In meq		As a % of the total				
					Ca ++	Mg ++	Total	Ca ++	Mg ++		
112	5—12	6,87	6,1	5,3	2,17	1,04	3,21	67,1	32,9	3,36	1222
	20—25	2,29	6,0	5,3	1,32	0,72	2,04	65,3	34,7	2,10	982
	40—45	0,75	6,1	5,3	0,96	0,48	1,44	67,2	32,8	1,46	808

Note: Comma represents decimal point.

um humates and fulvates, that create a good structure and help to coagulate humus. The humus of arctic soils is highly soluble.

Particle-size analysis (Table 3) shows that sandy loam types predominate among the humus arctic soil. The fine sand fraction predominates everywhere. There is little variation in texture throughout the profile. There is no accumulation of the clay fraction in the upper horizon under zonal conditions (profile 147) and at a depth of 20 cm in the local depressions (profile 182). Enrichment of the clay fraction in the upper soil horizons indicates the presence of biochemical weathering under these severe conditions.

In more favorable sites on well-drained slopes from a southerly aspect, humified sod arctic soils develop. On these sectors the vegetation forms meadows in the ditches of small hexagonal polygons. The vegetation is more varied than on the humus arctic soils. There are often shrubs as well as mosses and grasses. The following morphological description of a humified sod arctic soil is given.

Profile 112. Bolshevik, coast of Solnechnaya Bay. Surface of twenty meter marine terrace. Shrubs and mosses along the polygonal fissures. Diameter of polygons, 15-20 cm.

A₀ 0-2 cm. Dark grey, sandy loam, structureless, friable, fresh; the horizon can only be traced along the polygonal fissures. Unsharp transition.

A₁' 2-12 cm. Cinnamon-brown to brown, sandy loam, non-stable block-like, compacted, with roots and small gravel. Gradual transition.

tion.

A₁' 12-26 cm. Grey-brown, fine sand, structureless, compacted, moist, occasional roots and small gravel. Gradual transition.

B 26-40 cm. Yellow-brown, fine sand, structureless, damp, isolated roots and small gravel. Transition at the thawing boundary.

C 40-50 cm. Straw yellow with brown tinge, fine sand, compact, frozen, small gravel inclusions.

The quantity of organic matter is considerably higher in humified sod arctic soils than in low humus sod arctic soils (Tables 4, 5, 6). The humus horizon is also extended to the whole thickness of the active layer and it is only in permafrost layers that the humus content decreases to 0.7%. The reaction of these soils is weakly acid. Adsorption capacity is slight, owing to the coarse-texture of the soils. Degree of saturation is considerable, 96%-98%. Accumulation of available iron is better expressed than in typical arctic soils.

Fulvic acids only slightly exceed humic acids in humified sod arctic soils. Calcium humates and fulvates and free humic acids are very prominent in the humus composition.

Conclusions

1. On the maritime plains of Bolshevik (Severnaya Zemlya) sod arctic soils with the following features are formed: absence of excessively wet and gleying processes; weakly acid, almost neutral reaction of the medium;

Table 6

Particle size analysis of humified arctic soil, in %

Profile No.	Depth, cm	Diameter of particles, mm					
		1-0,25	0,25-0,05	0,05-0,01	0,01-0,005	0,005-0,001	<0,001
112	5-12	59,34	25,98	2,24	1,80	1,80	10,84
	20-25	62,26	24,52	1,87	0,56	1,30	8,80
	40-45	87,94	2,31	0,24	0,08	0,63	6,90

Note: Comma represents decimal point.

significant humus content in relation to the sparse vegetation; considerable extent of the humus profile; high saturation of the exchangeable complex of the soil and slight adsorption capacity; accumulation of available iron in the upper soil horizon.

2. A distinction can be drawn in this territory between low humus sod and humified sod arctic soils.

3. Sod arctic soils occupy the maritime lowland of the island. Rubble mountain arctic soils are found on other parts of the territory free from sheet ice.

Received September 23, 1959

BIBLIOGRAPHY

1. GORODKOV, B.N. 1956. The vegetation and soils of the island of Kotelny. In:

Vegetation of the Far North and its utilization. Izd. Akad. Nauk SSSR. No. 2. Moscow-Leningrad.

2. GORODKOV, B.N. 1958. The soil and vegetation of the island of Wrangel. Idem. No. 3.
3. IVANOV, I.M. 1931. Soil formations in the arctic. Trudy Instituta po izucheniyu Severa. No. 49, Gostekhizdat. Leningrad.
4. IVANOVA, YE.N. 1956. An attempt at a general soil classification. Transactions of the 6th International Congress of Soil Science. Moscow.
5. KOROTKEVICH, YE.S. 1958. The vegetation of Severnaya Zemlya. Botan. zh. Vol. 13, No. 5.
6. KOSHELEVA, I.T. and A.S. TOLSTUKHINA. 1957. Cultivation of soils in the Northern Ob Region. Pochvovedeniye, No. 2.
7. TYUTYUNOV, I.A. 1951. Migration of water in a peat-gley soil. Izd. Akad. Nauk SSSR. Moscow.

MICROELEMENT CONTENT IN CERTAIN SOILS OF THE VLADIMIR REGION

V. YAKUSHEVSKAYA, Moscow State University

The soils of the Vladimir region are very regular and of comparatively high fertility. They are intensively farmed. Dark grey forest and meadow black soils are distinguished in particular. These soils have brought fame to the Vladimir region as a northern "island" of chernozem. A study of the microelements in these soils is therefore of particular interest.

We determined the microelement content in dark grey forest, dark meadow and dark meadow-gley soils. The soil profiles were taken along a line running across the top of a watershed and a very gentle slope of westerly exposure (Shapilovo in the Yur'yevskiy district of the Vladimir region). The summit and upper part of the slope (Profile 239) are plowed and occupied by spring wheat. Eye witnesses state that the area was oak forest approximately 60 years ago. The soil is dark grey forest soil. The middle and lower part of the slope is meadow with lush herbaceous and grass vegetation. The soils of the meadows and dark meadow in the central sector (Profile 2) and dark meadow-gley lower down (Profile 3). They are all clay loams on loess-like carbonate clay loams (3).

The dark grey forest soil has a grey powdery top plowed layer and a dark brown nutty B horizon. Silica powdering is quite clearly visible both in the upper and in the illuvial horizons. Humus content (Table 1) is slightly lower than usual but the remaining properties conform to those of soils of this type. A slight increase in the total phosphorous content should perhaps be mentioned.

The dark meadow soil has a dark grey, almost black humus horizon approximately 30 cm thick, a granular structure that penetrates in clumps and projections into the underlying brownish-dark brown small nutty B horizon. The O_2 concretions appear at a depth of 60-70 cm. Effervescence from 60 cm (in spots) and continues from 100 cm. There are slight signs of gleying in the lower part of the B horizon (in 95 to 100 cm). Ground waters lie at a depth of 120 cm.

The features of dark meadow-gley soil are a distinctly thicker humus horizon, absence of O_2 concretions and effervescence, clearly marked gleying and a higher level for ground waters (approx. 90 cm).

The properties of meadow soils are largely determined by the nature of the soil and ground waters. These waters are here weakly alkaline, moderately hard and almost devoid of iron and organic matter (Table 2). A continual subflow of these waters maintains a neutral reaction in the soil solution and a high degree of base saturation (Table 3). Both meadow and meadow-gley soils are rich in humus (especially the latter) and have a high adsorption capacity. Biogenic accumulation of calcium and phosphorus is fairly apparent. There is a typical accumulation of aluminum and iron in the B horizon.

All the soils studied contain enhanced amounts of copper, titanium and manganese and reduced amounts of cobalt and chromium (Table 4). The quantity of nickel, lead and vanadium is approximately the same as in chernozems (we took the average content of microelements in thick chernozems as our standard) (2). One should note that there is slightly more vanadium than chromium, which is the reverse of the normal (1). This microelement composition in the soil is mainly inherited from the parent material. The loess-like carbonate clay loam of the Vladimir region is rich in copper and titanium and a little low in chromium and cobalt. There is a direct correlation between the composition of the soils and the parent materials that is fairly well maintained: even the proportions of chromium and vanadium and cobalt and nickel coincide.

The common features of the microelement composition of all the soils studied are due to the uniformity of the parent materials, the nearness of the soil profiles and the genetic link of the soils. Differences in content and distribution are due to features in the soil-forming process. These differences are revealed both in the geomorphological profile and in the distribution of microelements throughout the genetic horizons.

Copper is highest in the meadow gley soil with the highest humus content (Table 4). The distribution of nickel and copper throughout the profile (geomorphological) reflects the humus content. Biogenic accumulation of nickel and copper is here quite clearly revealed. Titanium, manganese, vanadium, chromium, and lead are fairly evenly distributed throughout the geomorphological profile. Titanium, manganese, and lead predominate slightly in grey forest soils. This distribution is associated with considerable manganese accumulation in leaves and needles

Table 1

Chemical properties of dark grey forest clay loam cultivated soil of the Vladimir region. Profile 239.

Horizon	Depth, cm	Humus	Total nitrogen in %	C : N	Total content in % of the ignited sample										Adsorbed cations in med per 100 g of soil			pH	
					SiO ₂	R ₂ O ₃	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	SO ₃	P ₂ O ₅	Ca++	Mg++	Ca++ + Mg++ + H+ (hydr)	Water	Salt		
Amax	0—20	3,44	0,20	10	80,16	15,97	11,49	4,24	1,20	1,15	0,50	0,24	17,21	3,80	22,55	6,8	6,1		
Amax	11—21	3,44	0,21	9	—	—	—	—	—	—	—	—	16,93	3,61	22,40	6,8	6,0		
A ₁	30—40	2,59	0,16	9	78,98	16,55	11,15	4,91	1,25	1,72	0,47	0,28	18,45	3,79	23,73	6,7	6,1		
B ₁	50—60	0,65	—	—	78,31	17,14	11,51	5,35	1,07	1,27	0,40	0,28	11,27	2,37	15,38	6,5	5,6		
B ₂	70—80	0,30	—	—	77,60	19,07	12,76	6,07	1,03	1,86	0,26	0,24	15,44	4,10	21,28	6,1	5,2		
B ₃	130—140	—	—	—	74,83	21,80	15,25	6,46	1,06	1,89	0,33	0,19	—	—	—	5,6	5,0		

Table 3
Chemical properties of dark meadow soils of the Vladimir region

Horizon	Depth, cm	Humus		C:N	Total content							Adsorbed cations in meq per 100 g. of soil				pH		CO ₂ in %	
		Total nitrogen	in %		SiO ₂	R ₂ O ₃	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	SO ₃	P ₂ O ₅	Ca++	Mg++	Ca+++ + Mg+++ + H+ (hydr)	Hydrolytic acidity, meq	Water		Salt
Profile 238																			
A ₁	0-10	6,36	0,39	9	77,72	17,94	12,76	5,35	2,14	1,09	0,94	0,27	29,38	5,71	36,44	1,35	7,1	6,5	None
A ₁	10-20	5,50	0,37	8	75,27	17,70	12,92	4,59	1,89	0,93	0,49	0,20	29,79	5,28	35,81	0,74	7,4	6,4	"
B ₁	25-35	1,72	0,12	8	74,35	21,07	16,09	5,48	1,92	1,16	0,56	0,13	23,32	5,13	28,84	0,39	7,4	6,4	"
B ₂	50-60	0,71	—	—	74,37	20,69	14,14	6,19	1,84	0,98	0,45	0,36	28,23	5,59	33,82	None	7,7	7,2	0,62
B ₃	70-80	0,30	—	—	74,86	21,20	13,83	7,13	2,63	1,44	0,48	0,24	—	—	—	"	7,8	7,2	0,86
B _g	100-110	—	—	—	74,19	21,45	15,72	5,59	2,62	2,59	0,90	0,14	—	—	—	"	8,1	7,2	1,08
Profile 240																			
A ₁	0-10	10,03	0,74	8	—	—	—	—	—	—	—	—	44,25	7,86	53,79	1,68	7,1	6,9	—
A ₁	15-25	5,86	0,42	8	—	—	—	—	—	—	—	—	39,23	6,74	46,69	0,72	7,2	6,6	—
B ₁	35-45	2,00	0,12	9	—	—	—	—	—	—	—	—	26,15	5,99	32,51	0,37	6,9	6,5	None
B _g	55-65	0,68	—	—	—	—	—	—	—	—	—	—	20,38	5,81	26,37	0,18	7,4	6,8	None
B _g	75-85	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0,23	7,4	6,6	"
G	100-110	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0,33	7,4	6,4	"

Note: Comma represents decimal point

MICROELEMENT CONTENT

Table 2

Composition of soil and ground waters, dark meadow soil of the Vladimir region

Profile Number	pH	Solid residue, mg/l	In mg/l							In meq/l						
			HCO ₃ '	SO ₄ "	Cl'	HSiO ₃ '	R ₂ O ₃	Ca++	Mg++	HCO ₃ '	SO ₄ "	HSiO ₃ '	Ca++	Mg++	Na++K+	Hardness
238	7,78	200	190	23	None	15	Traces	39	18	3,11	0,48	0,19	1,95	1,48	0,35	3,43
240	7,78	222	230	16	"	13	"	41	12	3,77	0,33	0,17	2,05	0,98	1,24	3,03

Note: Comma represents decimal point.

Table 4

Content of microelements in soils (hor. A) and parent material, mg per kg of soil

Soil, parent material	Depth, cm	Cu	Co	Ni	V	Cr	Pb	Ti	Mn
Dark grey forest, Profile 239	0—10	30	<5	20	140	120	24	6200	1700
Dark meadow, Profile 238	0—10	37	<5	22	130	90	19	5500	1100
Dark meadow-gley, Profile 240	0—10	76	<5	29	120	100	20	5500	980
Thick chernozem (standard)		56	8	39	150	400	23	4100	900
Loess-like carbonate clay loam		65	<5	30	140	100	19	4500	700

Note: Spectral analyses. Data calculated for a sample ignited at 450°C. Analyst N. L. Somova

Table 5

Distribution of microelements throughout the soil profile, mg per kg of soil

Horizon	Depth, cm	Cu	Co	Ni	V	Cr	Pb	Ti	Mn
Profile No. 239									
A	0—10	30	<5	20	140	120	24	6200	1700
	30—40	73	<5	25	140	130	25	6200	4000
B	50—60	75	<5	30	160	110	22	5400	800
	70—80	—	<5	31	140	110	22	4400	1100
Profile No. 238									
A	0—10	37	<5	22	130	90	19	5500	1100
	10—20	30	<5	26	120	100	21	5200	1300
B	25—35	49	<5	30	140	100	21	4700	800
	70—80	65	<5	30	170	130	22	3900	900
	100—110	30	<5	37	210	160	24	5400	800
Profile No. 240									
A	0—10	76	<5	29	120	100	20	5500	980
	15—25	>23	<5	25	130	110	21	5000	1100
B	35—45	85	<5	32	180	130	22	5000	800
	75—85	98	<5	23	170	130	21	5800	600
	100—110	100	<5	29	130	110	21	5800	800

Note: Spectral analyses, calculated for a sample ignited at 450°C. Analyst N. L. Somova. Sensitivity: Cr - $1 \times 10^{-3}\%$; Ni - $1 \times 10^{-3}\%$; Co - $5 \times 10^{-4}\%$; Cu - $1 \times 10^{-3}\%$; Pb - $1 \times 10^{-3}\%$; V - $1 \times 10^{-3}\%$.

Table 6

Particle-size analysis of dark meadow soil in % of an absolutely dry sample. Profile 23C.

Depth, cm	Pre-treatment loss, %	Diameter of particles, mm						
		>0,25	0,25-0,05	0,05-0,01	0,01-0,005	0,005-0,001	<0,001	<0,01
0-10	6,84	—	13,57	32,01	9,53	12,55	26,60	48,68
10-20	6,74	—	—	41,10	11,24	12,33	28,59	52,16
50-60	6,37	—	—	36,73	13,30	9,66	33,94	56,90
70-80	6,59	—	—	38,06	13,09	9,41	32,85	55,35
100-110	8,88	—	—	45,99	1,70	8,81	34,62	45,13

Note: Comma represents decimal point.

and, therefore, in the humus horizons of forest soils (1). There is relative titanium accumulation in podzolized gray forest soils as a residual accumulation element (2). There is mention in the literature of a high lead content in grey forest soil (1), but no explanation has been given. No conclusions on quantitative variations can be drawn from the data for cobalt content.

The distribution of microelements throughout the genetic soil profile is largely dependent on the chemical composition of the horizons and is different in different soil groups. In all the soils studied there was some accumulation of microelements in the lower part of the soil profile (Table 5). There are various reasons for this general tendency in the distribution of microelements throughout the profile in different soils. In dark grey forest soil, for example, it is due to the comparatively high humus content, the presence of an illuvial horizon and, possibly, to some residual hydromorphism; in meadow soils the reason is extensive hydro-genetic accumulation, that is more extensive even than biogenic accumulation. Only manganese was found to be accumulated in the humus horizons of the soils studied. In the A_1 horizon of dark grey forest soil there was also slight accumulation of titanium and lead. Nickel, vanadium and copper are accumulated in the illuvial horizon with iron. Chromium is fairly evenly distributed. The direct correlation in the distribution of iron and chromium throughout the profile mentioned in the literature (1) was not found in this case.

Despite the high humus content and intensive biogenic accumulation, microelements were not found to predominate in the humus horizon of dark meadow soil. The majority of the microelements, except Ti and Mn, even have a slight maximum in the lower part of the profile. This distribution is associated with the ground-water level near the surface that causes hydro-genetic accumulation in the gley horizons and in the capillary fringe horizons. Thus hydro-genetic accumulation seemingly masks biogenic accumulation and leads to relative smoothing out of the "microelement" profile. In our case there is a very slight predominance of hydro-genetic accumulation even for titanium (second maximum). The distribution pattern for iron and copper is approximately the same as for vanadium and chromium. There is a direct correlation between the clay content (Table 6) and

such microelements as V, Cr, Ni and Cu.

In dark meadow-gley soil hydro-genetic accumulation is even more marked. The accumulation of microelements (Ni, Cr, V) begins in the upper part of the transitional horizon. In the gleying horizon itself the copper content is increased and the titanium and nickel maximum reached in the B_g horizon is maintained. The quantity of lead remains practically the same throughout the profile. Manganese, as already mentioned, is slightly higher in the humus horizon.

Both the content and the distribution pattern for microelements throughout the profile of meadow, meadow-gley and dark grey soils in the Vladimir region agree with our data for similar soils in other districts and with accounts in the literature (2, 4, 5).

Conclusions

1. The content of microelements in these soils of the Vladimir region is due in the main to the nature of the parent materials, while distribution throughout the profile is associated with the features of soil formation; thus, despite the high humus content of meadow soils, hydro-genetic accumulation of microelements predominates (soils of the hydromorphic subtype); in dark grey forest soils accumulation is mainly associated with the biological cycle and the illuvial process.

2. The content of the majority of microelements in dark grey forest and dark meadow soils in the Vladimir region is approximately the same as in thick chernozems. These soils can be looked up as well provided with microelements (in total form). Special studies should be made of the availability of the microelements and their assimilation by plants.

3. Variations in the microelement composition both in different soils as a whole and in their genetic horizons do not exceed one order of magnitude, and no differential approach is therefore required in practice.

Received June 8, 1959

MICROELEMENT CONTENT

BIBLIOGRAPHY

1. VINOGRADOV, A. P. 1957. The geochemistry of rare and trace elements in soils.
2. KOVDA, V. A., I. V. YAKUSHEVSKAYA, and A. N. TYURYUKANOV. 1957. Microelements in the soils of the Soviet Union. Mss. Moscow State University.
3. YAKUSHEVSKAYA, I. V. 1956. The soils of the Vladimir region. Author's summary of thesis.
4. MITCHELL, R. L. 1955. Trace elements. Chemistry of the soil. New York. In English.
5. WALSH, PIERCE, RYAN and FLEMING. Co deficiency in soils in relation to weathering processes. (Russian translation of Proc. 4th Congress of Soil Science, Paris). Report to Commission II. Vol. 6.

EFFECT OF PRELIMINARY CAPILLARY WETTING ON THE SWELLING AND WATER STABILITY OF SOILS

V. I. BOBCHENKO, All-Union Research Institute for Hydrotechnical Engineering and Melioration

The influence of moisture of soils on their water stability has been examined in papers by Kachinskiy (Nikolayev's data, 2), Petrov (4), Frantsesson (5), Vershinin (1), and other workers. It has been found that the water stability of soils is enhanced if they are subjected to preliminary capillary saturation. Smaller settling volumes were recorded (5) for rapid wetting followed by drying out than for slow wetting.

We have studied the influence of capillary tension ("negative pressure") on the swelling and water stability of soil in order to find out under what conditions the arches of mole drains and mole irrigation channels used in melioration will be water stable.

We took 60 x 60 x 40 mm soil samples for our tests. These samples were arch models of mole drains and channels. The models were made of crumbled soil at a pressure of 50 kg/cm² and the arch of the mole drain was pressed out in the lower part.

The samples (models) were preliminarily wetted on fine sand, which was moistened to a given depth. Different levels of capillary tension (negative pressure) were created by feeding the water into the sand at different depths. These treatments were provisionally grouped as: "low capillary tension"—at a depth of 1 mm, "medium"—at a depth of 20-25 cm, "high"—at a depth of 40 cm.

After capillary wetting for 24 hours under the conditions described for each treatment (the samples were wetted throughout their height) all the samples were kept for another 24 hours under the same conditions of "low" capillary tension. They were then tested for breakdown in water for 24 hours.

The horizontal cross section and height of the samples were measured three times, accurate to within 0.5 mm to determine swelling: after wetting, after initial wetting at the capillary tension for the given treatment, and after secondary wetting under equal conditions at low capillary tension.

Table 1 shows both the great importance of preliminary capillary wetting for the water stability of soils, and the marked influence of the capillary tension at which wetting is carried out.

High capillary tension helps to create the highest water stability. This agrees with the differing rates of capillary wetting and the differing swelling volume of the samples. It is clear that high capillary tension creates favorable conditions for the removal of air from the soil by slowing down capillary wetting. On a par with this, high capillary tension helps to compact the soil particles and form them into the best aggregates.

In addition to the experiments described in Table 1, we made laboratory and field tests with sandy loam and clay loam sod-podzolic soils and typical weakly alkaline chernozems.

Similar results were obtained in these experiments, which were only slightly different in method, when the samples were repeatedly moistened by capillary wetting from below, and it was found that soils could be made water stable by preliminarily wetting them at "high" capillary tension.

It was also found that when soils were broken down by water the rate of preliminary capillary wetting influenced the natural angle of contact (in water). When capillary tension in preliminary wetting was made higher this angle was increased. Thus, for sod-podzolic soil, contact angle after destruction of the samples in water was as follows for the different treatment: without preliminary wetting, 31°; with "rapid" capillary wetting, 40°; with "average" capillary wetting, 44°. This was clearly due to better retention of large aggregates on preliminary wetting, especially when capillary tension was high.

The experimental results lead us to conclude that slow preliminary capillary wetting of the sides of canals, mole drains, and channels will considerably increase their water stability. Direct field observations confirm this assumption. In the Kursk region on typical chernozem, for example, the stability of artificial mole irrigation channels was considerably improved by irrigating the surface with 300-400 m³/ha several days before their use.

When using mole drains to leach saline soil small quantities of water should clearly be used for preliminary wetting, so that the moisture from the moist upper horizons should spread slowly under high tension to the level of the drains and increase their stability when in use.

PRELIMINARY CAPILLARY WETTING

Table 1

Effect of capillary attraction (negative pressure) in preliminary wetting on swelling and the water stability of soils

Soil	Initial moisture content, %	Treatment of capillary attraction	Average movement rate of the capillary fringe on wetting, mm/min	Swelling volume, %		Degree of retention of the samples after 24 hours in water (water stability)
				After wetting		
				For initial conditions	Under equal conditions	
Clay loam chestnut	9,2	Without preliminary wetting (control),	—	—	—	Destroyed.
		"low",	4,0	53,0	53,0	Destroyed. Refined, slight destruction (3 mm) in the corners of samples
		"medium"	1,3	11,0	21,8	
		"High", without preliminary saturation (control),	0,2	7,0	28,0	Totally retained
Ciscausian fine clay loam chernozem	8,9		—	—	—	Destroyed.
		"low"	2,2	40,0	40,0	All corners and faces of the samples destroyed and more than 50% of the side walls
		"Average"	0,2	12,2	21,0	Retained, small fissures developed.
		"High" without preliminary wetting (control),	0,1	8,0	21,0	Not determined.
Ciscaucasian fine clay loam chernozem	14,1		—	—	—	Destroyed.
		"low"	—	43,0	43,0	Retained, large fissures developed.
		"average"	—	13,8	19,0	Retained, small fissures developed.
		"High"	—	5,0	11,0	Fully retained.

Note: Comma represents decimal point.

It is no less important to consider the role of capillary attraction in preliminary wetting of soil samples for microaggregation analysis and so when determining water stability, contact angles, soil erodibility, etc.

Conclusions

1. When soils are preliminarily wetted, the tent of capillary tension (negative pressure) exerts a considerable influence on the volume of swelling, water stability and the size of contact angle in water.

2. The properties of soils can be considerably affected by preliminary capillary wetting, and this is of practical interest.

BIBLIOGRAPHY

1. VERSHININ, P. V. 1958. Soil structure and the conditions of its formation. Izd. Akad. Nauk SSSR.
2. KACHINSKIY, N. A. 1927. Freezing, thawing and soil moisture in the winter in forests and fields. Moscow.
3. KACHINSKIY, N. A., A. F. VADYUNINA, and Z. A. KORCHAGINA. 1950. Experimental agricultural physical description of soils based on the Central Urals. Izd. Akad. Nauk SSSR. Moscow-Leningrad.
4. PETROV, YE. G. 1927. Study of the water permeability of soils. NAZH. No. 4.
5. FRANTSESSON, V. A. 1942. Swelling and shrinkage in chernozems in relation to structural stability. Pochvovedeniye, No. 1.

Received July 22, 1959

AN ELECTROMETER FOR MEASURING GRADIENT HEAD WHEN DETERMINING SOIL PERMEABILITY

V. M. ALEKSEYEV, V. D. BERDYSHEV, and V. S. BOGOMOLOV, Voronezh Constructional Engineering Institute

The majority of field methods for determining the infiltration coefficient are based on measurement of the volume of water flowing through a given area. Calculation of the infiltration coefficient in existing methods is based on the assumption that the gradient head is equal to unity by the formula:

$$K\phi = \frac{Q}{\omega},$$

where Q is the volume of the filtrated water, ω is the sectional area of the ring. This concept does not, however, agree with the physical picture of the filtration of water in soil material.

Calculation of the infiltration coefficient by Zunker's formula (5) can be taken to be more exact:

$$K\phi = \frac{Q}{\omega} \cdot \frac{Z}{\alpha Hk + h + Z},$$

where α is Bindemann's correction; Hk is the height of capillary rise; h is the thickness of the water layer on the surface; Z is the depth to which the water has permeated at a given moment.

There are known difficulties in finding the values α , Hk and Z when determining the gradient under field conditions. In the infiltration devices of Poltev and Varizashvili (2) these difficulties are eliminated by measuring the gradient directly. These instruments enable one to measure the hydrostatic pressure at a given depth below the surface by a water or mercury manometer. This method is similar to the determination of the infiltration coefficient in removed soil profiles and does not allow for the influence of the lower layers of the soil material.

We have developed another method for determining water permeability, in which the height of capillary rise does not have to be measured and the depth of permeation is determined during the test. In Vedernikov's view (3) the whole filtration zone can be divided into 2 parts: the capillary fringe and a zone of continuous gravitational flow. The boundary between them is the line of zero potentials, at which point, from Zunker's equation, the parameter Hk can be excluded. The moisture of the soil at the interface between the capillary and gravitational zones

changes, thus giving rise to a change in the resistance (or the opposite quantity — electrical conductivity) of the ground.

The point at which the boundaries of the gravitational zones pass through this horizon can be determined by locating the contacts of a megometer at a known depth and measuring the change in the resistance of the soil. The coefficient of infiltration will then be defined by the equation:

$$K\phi = \frac{Q}{\omega} \cdot \frac{Z}{Z + h},$$

where the discharge Q is determined for the moment at which the gravitational flow passes through the plane of the contacts.

Figure 1 shows curves of the change in the resistance of the soil obtained by us when determining the permeability of clay loam and slightly permeable silty clay loam. The experiments were conducted in the field and under

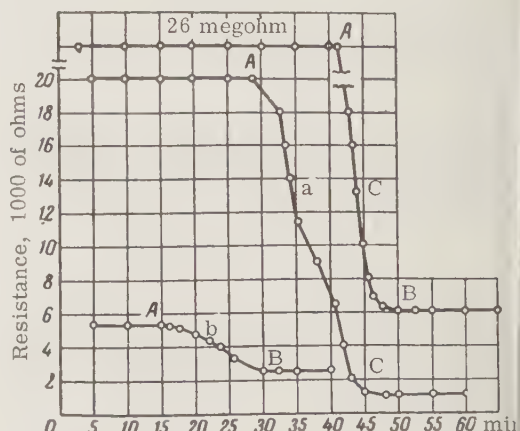


Fig. 1 - Curves of the change of the electrical resistance of the ground during infiltration: a - clay loam with an initial moisture $W = 7\%$; b - capillary wetted clay loam; c - silty clay loam of low permeability; A - beginning of capillary saturation; B - beginning of gravitational flow.

DETERMINING SOIL PERMEABILITY

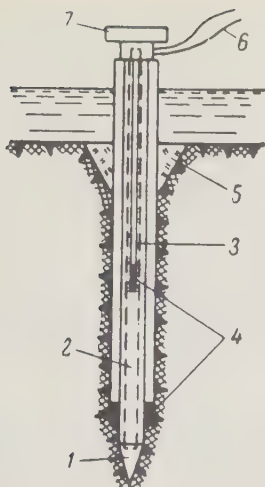


Fig. 2 - The electroprobe

1 - metal head; 2 - 12 mm diameter metal rod; 3 - plastic casing with electrodes; 4 - copper electrodes; 5 - hydro-insulation; 6 - electrode leads; 7 - metal cap.

laboratory conditions in vertical infiltration equipment in which the contacts were situated at depth of 40 cm. Point A marks the beginning of capillary saturation and point B the beginning of gravitational flow through the plane of the lower contacts. Passage of the gravitational flow cannot be assessed from the point at which the resistances become constant.

For field measurements we constructed a probe with 2 pairs of contacts attached to the megohmmeter by a cable. The probe is driven to the required depth with the infiltration ring (Fig.

To eliminate inflow down the sides of the probe we used a special grease of the following composition: 65% bituminous shale resin by weight, 25% colophony, and 10% paraffin. The mixture was heated until it liquified and the molten mass was poured round the probe as shown in Figure 2. Tests showed that this infiltration reliably excludes filtration down the

sides of the probe in the soil.

Any megohmmeter with a 500-20,000 ohm operational range can be used to measure the electrical resistance of the soil, but an ac generator must be used to eliminate the possibility of polarization of the contacts. The rate of infiltration need not be calculated constantly, but at the moment of approach of the gravitational flow to the first and second pairs of contacts. The infiltration coefficient is calculated by the formula:

$$K\phi = \frac{v\phi \cdot Z}{Z + h} \text{ cm/sec}$$

where $K\phi$ is the infiltration coefficient of the soil, $v\phi$ is the infiltration rate in cm/sec; Z is the depth in cm to which the water has permeated at a given moment; h is the thickness of the water layer on the surface in cm.

Received January 3, 1959

BIBLIOGRAPHY

1. BINDEMAN, N. N. 1947. Determination of the infiltration coefficient of rocks by infiltration from bore holes. Moscow.
2. VARIZASHVILI, G. S. 1952. A field method for determining the infiltration coefficient of cohesive soil material. Zh. gidrotekh. stroitel'stva. No. 12.
3. VEDERNIKOV, V. V. 1947. Results of a study of the physical picture of free infiltration. Dokl. Akad. Nauk SSSR. Vol. 55, No. 3.
4. KLYCHNIKOV, V. M. 1952. A device for measuring the permeability of soils under field conditions. Pochvovedeniye, No. 9.
5. ZUNKER, F. 1937. The behavior of water in the soil. Sbornik: Vodnyye svoystva pochv. Moscow.

SOIL MOISTURE DETERMINATION BY GAMMA RADIATION

YAN. CHABART, Melioration Research Institute, ChSASKhN, Prague

The determination of soil moisture by gammascopy is common in many countries. The new method, which is fairly accurate and inexpensive, has also come into use in Czechoslovakia.

The principal advantage of the method is that soil moisture can be determined directly in the field. Another advantage is that it can be used for systematic recording of the dynamics of soil moisture without obtaining samples. The classical method of determining moisture by weight is no longer satisfactory. Repeated digging or boring of holes interferes with the natural pattern of soil moisture dynamics and makes it impossible to obtain additional samples from the same place. Moreover, samples obtained from an unduly wide area do not provide a completely accurate idea of the moisture regime. A further shortcoming of the method is that repeated boring injures the vegetation. Yet a frequent objective of scientific research is to determine the influence of vegetation on the dynamics of moisture in the uppermost layers of the soil profile. The gamma-radiation method completely does away with these shortcomings. The recording device and radiation source are set into the ground and the moisture is determined throughout the irradiated layer. We began our experiments with vertical irradiation (Fig. 1) since it was particularly important for us to study changes in the moisture content of the top layer.

Thus far the moisture content determination by gamma radiation has been expressed in millimeters of the water column or, through conversion, as a percentage. The latter, used in investigating moisture dynamics, is derived from the following formula:

$$h_g = \frac{(\ln I_0 - \ln I_t) \cdot 100}{\mu \cdot g \cdot v},$$

where h_g is the deviation in moisture from the initial value established in percentages by the weight method; $\ln I_0$ is the natural logarithm of the initial number of counts; $\ln I_t$ is the natural logarithm of the number of counts in individual determinations; μ is the linear coefficient of water adsorption; g is the bulk density of the soil; g is the thickness of the layer irradiated,

tained by adding the initial moisture determined by the weight method h_p to the deviation therefrom h_g determined by the gamma-radiation method.

$$h = h_p + h_g$$

We then conducted experiments with the vertical irradiation in the laboratory. The diagram of gamma radiation measurement of soil moisture is shown in Figure 2. The experiments were performed October 6, 1958 on a 50 cm layer of loose cultivated soil gradually wetted with two liters of water. The moisture was checked 24 hours later. A series of 5-minute measurements was made for each determination and the arithmetic mean calculated. The resultant values were recalculated for one minute, a correction being introduced into the natural background of the Geiger-Müller counter. The series of measurements had to be made in order to eliminate the deviations arising from uneven radiation source of gamma-ray. Since the experiments involved loose soil, each determination required establishment of soil setting and bulk density. This is unnecessary in connection with measurements in soil with natural structure.

We used a Geiger-Müller MC-6 tube for recording with a B-2 annunciator. Cobalt Co^{60} (with an intensity of 5 meq Ra) was the source of radiation. The linear coefficient of water absorption $\mu = 0.058$ was obtained by collimation with a lead container, opening 8 mm in diameter, and a lead diaphragm. The soil moisture in Table 1 was computed as percentages according to the formula.

Table 1 shows the great accuracy of determination by gamma radiation. These results can be achieved only with strong collimation, which can be created by vertical irradiation in the field as well. Deviations in gamma measurements from the computed moisture content were in tenths and hundredths of a percent depending on the amount of water added. The moisture content can be directly read as a percentage with the help of the graph shown in Figure 3.

The absolute water content in the soil is ob-

Received February 18, 1959

SOIL MOISTURE DETERMINATION

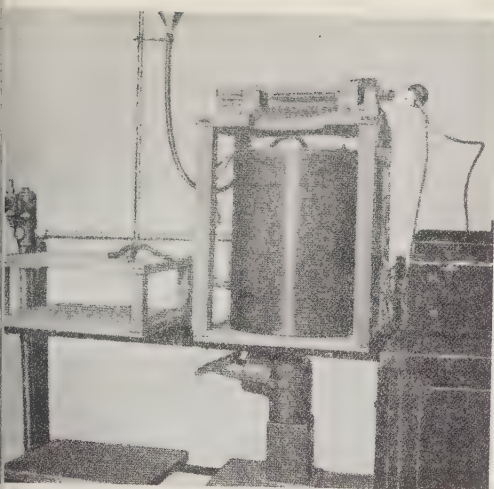


Fig. 1. - Apparatus for vertical determination of soil moisture by gamma radiation (photograph by K. Shand).

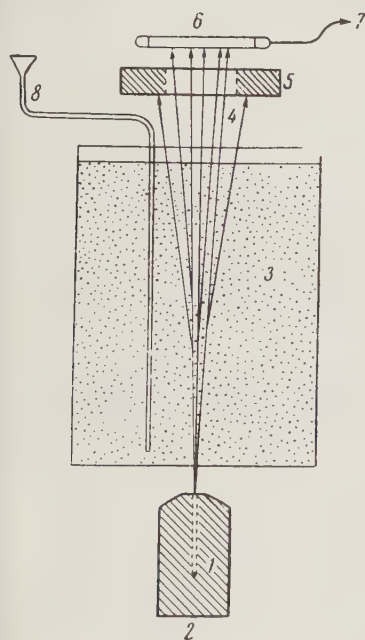


Fig. 2. - Diagram of determination of soil moisture by the vertical method using gamma radiation

1 - source of radiation; 2 - container-collimator; 3 - soil; 4 - gamma rays being emitted; 5 - lead collimator; 6 - counter (Geiger-Müller tube); 7 - connection for recording apparatus; 8 - device for gradual wetting the soil.

Table 1
Direct conversion of recorded counts as percentages of moisture

I_t	Date water added	Water added, liter	Number of counts per minute	Bulk density	Thickness of soil, (cm)	Gamma determination of moisture, %	Actual moisture, %	Deviation
I_0	Oct. 6	—	462	1,042	50	—	9,88	—
I_1	Oct. 7	2,00	421	1,063	49	12,88	12,94	0,06
I_2	Oct. 11	2,00	380	1,063	49	16,35	15,99	0,36
I_3	Oct. 14	2,00	348	1,086	48	19,25	19,05	0,20
I_4	Oct. 18	2,00	318	1,086	48	22,23	22,10	0,13
I_5	Oct. 23	2,00	287	1,109	47	25,62	25,16	0,46
I_6	Oct. 29	2,00	265	1,133	46	28,27	28,22	0,05
I_7	Oct. 31	2,00	241	1,133	46	31,48	31,27	0,21

Note: Comma represents decimal point.

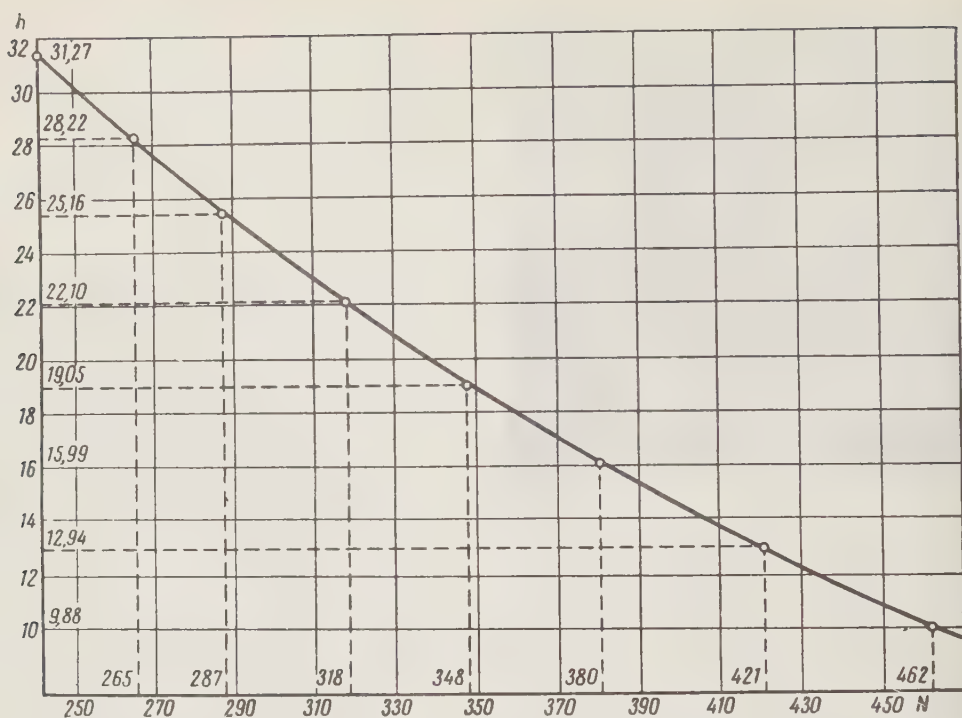


Fig. 3. - Graph showing the relationship between the number of counts and soil moisture expressed in percentages

N - recorded number of counts per minute; h - gamma radiation determined soil moisture in percentages.

BIBLIOGRAPHY

1. YEMEL'YANOV, V.A. 1958. Methods of radioactive radiation and indicators in soil melioration research. Moscow.
2. DANILIN, A.I. 1957. Use of nuclear radiation in hydrometeorology. Leningrad.
3. DANILIN, A.I. 1955. Measurement of soil moisture by gamma rays. Pochvovedeniye, No. 7.
4. MARTINETS, I. 1956. Evaluation of the accuracy of gamma-ray measurements. Vodnoye khozyaystvo. Prague.
5. SHABART, YA. 1958. Measurement of soil moisture by gamma radiation and how to increase the accuracy of the method. Sb. ChSASKhN - Lesnitsvi, Vol. IV, No. 8, Prague.

COLORIMETRIC DETERMINATION OF THE PHOSPHORUS IN SOILS AND PLANTS

A. MEL'TSER, Moscow State University

The established method for the colorimetric determination of the salts of orthophosphoric acid by reduction of a complex of phosphorous and molybdenum compounds by stannous chloride in phosphorus-molybdenum blue has been repeatedly varied (7, 8). However, the method still has a number of fundamental drawbacks, the most important of which are: unstable coloration of the solutions causing variation in the intensity of the blue color, development of turbidity in relation to the quantity of stannous chloride added, a marked decline in the intensity of coloration in the presence of small quantities of oxidizing agents, etc. (9). It has therefore, naturally, been found necessary to look for another method without these drawbacks.

The method here proposed for the colorimetric determination of phosphorus by the vanadium-molybdenum complex (yellow color) in a nitrate medium has the advantages of great simplicity, high sensitivity and stability of coloration in the solution (15), which is retained for 3 days (3). The method can be used to determine phosphorus in soils, plants, waters, minerals, rocks and other materials, in quantities ranging from thousandths of a percent to 2% (11).

Principle of the Method. Phosphoric acid forms a complex soluble salt $[P_2(V_2O_6)(Mo_2O_7)_{11}]^{14}$ in the presence of the anion of vanadic acid and ammonium molybdate (7), which colors the solution yellow. The time required for development of maximum coloration and stability of coloration depend on the nitric acid concentration in the solution. Several authors (3, 10) have found that the addition of 5 ml of nitric acid (sp.g. 1.4) to 100 ml of solution leads to the development of maximum coloration within 2-3 minutes and that the color remains stable, as mentioned, for 5-6 days.

The determination is hindered by ferric iron, which (at high concentrations) yields a yellow color in a nitrate solution. The presence of large quantities of silicic acid yields exaggerated results, owing to the formation of a yellow complex compound with the reagent. If there are considerable quantities of organic matter in the solution their coloration will interfere. The coloration of the solution is lightened by the presence of sulfuric, acetic, and hydrochloric acids (11).

Since the solution should be colorless and the medium nitrate for colorimetric determination of phosphorus by a vanadium-molybdenum complex, these obstacles should be removed before colorimetry (see the section "Preparation of the material for analysis").

Reagents Required:

1. Nitric acid, sp.g. 1.4 (3, 10) free from the oxides of nitrogen. The latter are removed by placing glass capillaries in the bottom of a 1 liter glass beaker, which is filled approximately half full with nitric acid (sp.g. 1.4) and boiled for 0-40 minutes until the solution is colorless.

2. 25% ammonia.

3. Hydrogen peroxide, free from traces of phosphoric acid (13).¹

4. Previously purified activated charcoal (13).

5. 0.1 N solution of potassium permanganate.

6. A 5% solution of aluminum nitrate.

7. Powdered aluminum.

8. The reaction liquid. Two solutions are prepared:

1) 10 g of ammonium molybdate are dissolved in 100 ml of distilled water and heated to 50-60°C, after which 2 ml of nitric acid (sp.g. 1.4) are added carefully, the mixture being stirred continuously. If a precipitate appears it is filtered.

2) 0.3 g of ammonium vanadate are dissolved in 50 ml of distilled water and heated to 50-60°C. The solution is cooled and 50 ml of nitric acid (1:3) previously purified from the nitrogen oxides are added.

Solutions 1 and 2 are mixed and 15 ml of nitric acid (sp.g. 1.4) purified of the nitrogen oxides are added.

The reaction liquid is stored in a dark glass

¹According to Sokolov (12) hydrogen peroxide may contain as much as 0.4 mg of P_2O_5 per ml.

Table 1

Scale of standard solutions

Flask No.	Mls of standard solution	Content, mg	
		Phosphorus	Phosphorous pentoxide
0	0,0	0,00	0,000
1	0,1	0,01	0,023
2	0,2	0,02	0,046
3	0,3	0,03	0,068
4	0,4	0,04	0,092
5	0,5	0,05	0,114
6	0,6	0,06	0,137
7	0,7	0,07	0,160
8	0,8	0,08	0,183
9	0,9	0,09	0,206
10	1,0	0,10	0,229
11	1,1	0,11	0,252

Note: Comma represents decimal point.

bottle and can be kept for several months. If a precipitate develops a new solution is prepared.

Standard Solution of Potassium Hypophosphite. An 0.2197 g sample of mono-substituted potassium hypophosphite (chemically pure) is dissolved in a small quantity of water, transferred to a 500-ml volumetric flask, to which 10 ml of oxide free nitric acid (sp. g. 1.4) are added and made up to the mark with water. One ml of the solution corresponds to 0.1 mg of phosphorus or 0.229 mg of phosphorus pentoxide. 50 ml of the concentrated solution are taken in a calibrated pipette and made up to 500 ml with water in a volumetric flask. The standard solution thus prepared should contain 0.01 mg of phosphorus or 0.0229 mg of phosphorus pentoxide to 1 ml.

Preparation of a Scale of Standard Solutions. (Vasil'yev's method [3]). The following amounts of the standard solution of KH_2PO_4 are placed in 50-ml volumetric flasks, which should all be of the same shape and glass: 0; 9.1; 0.2; 0.3; ... 1.1 ml. Then 2.5 ml of purified nitric acid (sp. g. 1.4) are added to each flask, and the contents are made up to approximately 25 ml with water and stirred. Eight ml of the reaction liquid are poured off, the loss made good with water and the mixture once again thoroughly stirred. A stable yellow color will appear after 2-3 minutes and will last for 5-6 days.

Preparation of the Material for Analysis. Soil is prepared for colorimetric determination of the total phosphorous content in the same way as for total chemical analysis. To determine the available compounds of phosphorus the soil is pulverized and put through a sieve with 0.25 mm openings.

The preparation of plants for analysis depends on the combustion method ("wet" or "dry"). In wet combustion (Aleksandrova's method [1]) the plants are ground in a mill and subsequently passed through a sieve with 1-mm openings and treated with concentrated HNO_3 in a Kjeldahl flask until the organic matter is completely oxidized, i. e., until the solutions are colorless.

In dry combustion the plants are ground, placed in quartz or porcelain cups and ignited at below 400-450°C. Between 0.1 and 0.5 g are taken as a sample, in relation to the assumed phosphorous content.

The production of colorless clear solutions is an essential prerequisite for colorimetric determination of phosphorus by the vanadium-molybdenum method (yellow color in a nitrate medium). When determining total phosphorous content in the soil after removal of silicic acid and also in acid and alkaline extracts after filtration, the solution is normally colored by the presence of iron and organic acids. According to Ginzburg (5) a content of more than 1.8 mg of ionic iron in the solution for colorimetry interferes with the analysis. The solution is made colorless by reducing the ferric iron to ferrous iron by adding powdered aluminum. An aliquot part of the filtrate (5-25 ml, according to the assumed phosphorus content) is placed in a porcelain cup, evaporated to dryness and treated 2-3 times with concentrated nitric acid to convert the precipitate to nitrates. Hot water is added (20-25 ml) to dissolve the precipitate; the solution is transferred to a 50-chemical beaker, boiled and removed from the heater. Powdered aluminum is added by a spatula. This reduces Fe^{+++} to Fe^{++} , thus making the solution colorless. The solution is then diluted with water, neutralized with ammonia (25%) until turbidity develops, after which a few drops of pure nitric acid (sp. g. 1.4) are added until the cloudiness disappears. The colorless solution is transferred to a 50-ml volumetric flask and subjected to colorimetry (see the section "Carrying out the Determination") (2).

One of the following methods is used to lighten extracts that are colored with organic matter: 1) oxidizing the organic matter by hydrogen peroxide (free from phosphorus); 2) adsorption by activated charcoal, and 3) oxidation by potassium permanganate, excess of which removes the color from sodium nitrate (10).

The hydrogen peroxide method is as follows. An aliquot part of the extract of from 1 to 20 ml (in relation to the assumed phosphorous content) is placed in a glass and acidified with nitric acid after which drops of purified hydrogen peroxide are added until the solution lightens; the excess peroxide is removed by boiling (10-15 min).

Another method is to boil the extract after adding 0.5 g of activated charcoal (purified from phosphorus) in a nitrate medium and to filter through a compact ash-free filter; the precipitate is washed in 0.1% nitric acid 2-3 times.

When potassium permanganate is used to decompose organic matter in the extract it is added while heating until a dark brown precipitate of manganese hydroxide is formed. The solution is cooled and the precipitate dissolved by the addition of small amounts of 5% sodium nitrate solution. Excess of the solution is destroyed by boiling until the dark brown nitrogen oxides are eliminated (10).

Carrying out the Determination. Between 1 and 20 ml of the solution (in relation to the assumed phosphorous content) prepared for colorimetry, i. e., clear and colorless, are placed in a 50-ml flask to which 2.5 ml of purified nitric

COLORIMETRIC DETERMINATION

Table 2

Comparative data for the determination of total P in plants by
Deniget's molybdenum sulfate method and by the
vanadium-molybdenum complex, %

Sample	P content	
	Deniget's method (blue color)	Vanadium- molybdenum complex (yellow color)
Sudan grass, tops	0,46	0,48
Natural meadow grasses, tops	0,62	0,62
Roots of meadow vegetation	0,68	0,70
Timothy, tops	0,68	0,67
Timothy roots	0,90	0,93

Note: Comma represents decimal point.

Table 3

Comparison of the determination of total P_2O_5 in soils by
gravimetric analysis and by colorimetry of a vanadium-molybdenum complex

Soil	Depth, cm	P_2O_5 , %	
		Gravimetric method (Lorentz)	Colorimetry of a vanadium-molyb- denum complex
Light chestnut	0—7	0,11	0,10
The same	10—21	0,14	0,12
The same	21—36	0,13	0,14
Solonetz	0—5	0,09	0,09

Note: Comma represents decimal point.

1 (sp. g. 1.4) and 2-15 ml of distilled water added. The solution is mixed, 8 ml of the reaction liquid are added. The solution is mixed, 8 ml of the reaction liquid are added, it made up to the mark with distilled water and thoroughly mixed once again. A stable yellow color that will not disappear for 5-6 days develops. Colorimetry is carried out after 2-3 minutes. Control determination is made at the same time as the analysis of the samples to enable corrections to be made to the results.

A scale of standard solutions can be used for colorimetry of available phosphorus under standard conditions and for multiple analyses. High-sensitive colorimeters (the FEK-M photometric colorimeter, photometers, etc.) are used under laboratory conditions. A blue filter is used with the FEK-M instrument. In visual colorimetry, calculations are made by the formula:

$$\%P = \frac{0.0001 \cdot a \cdot B}{A \cdot H} \cdot 100$$

where a is the scale reading in ml of the standard solution, A is the volume of the aliquot in ml, B is the volume of the volumetric flask containing the whole sample in ml, and H is the weight of the sample in g.

The result obtained is multiplied by 2.29 to convert the phosphorus determination to P_2O_5 (11).

Colorimetric determination of phosphorus by the vanadium-molybdenum method was repeatedly verified on samples of soils, plants, mosses, lichens, rocks, waters, etc. Both total phosphorus and its available forms were determined. The method has been tested by a number of scientific colleagues and post graduate students in the laboratory of soil science faculty in the Moscow State University. As an example we cite the following results for comparative determination of the phosphorus content in plants (Table 1) and soils (Table 2) by this and one of the previous methods.

Received January 31, 1959

BIBLIOGRAPHY

1. ALEKSANDROVA, L. N. 1949. The procedure for ash analysis. Probl. sov. pochvoved. No. 15.
2. ARINUSHKINA, YE. V. Rapid total chemical analysis. Mss.

3. VASIL'YEV, P.I. 1951. Methods for the rapid analysis of carbonate rocks. Ros-geolizdat.
4. GEDROYTS, K.K. 1955. Chemical analysis of the soil. Vol. 2.
5. GINZBURG, K.YE. 1952. Procedure for colorimetric determination of phosphoric acid in citric acid extracts from the soil. Pochvovedeniye, No. 12.
6. LEVITSKIY, A.YU. 1927. A colorimetric method for determining phosphoric acid. Nauchno agronom. zh. No. 11.
7. MAKSIMOVA, N.V. and M.T. KOZLOVSKIY. 1947. Composition of the phosphorous-vanadium-molybdate complex obtained in the colorimetric determination of phosphorous. Zh. analit. khimii. Vol. 2, No. 6.
8. MALYUGIN, A. and YE. KHRENOVA. 1928. Colorimetric determination of phosphoric acid. Nauchno agronom. zh. No. 5-6.
9. MESHCHERYAKOV, A.M. 1956. The use of thiourea for the colorimetric determination of phosphorus. Pochvovedeniye, No. 10.
10. POPOV, M.A. 1953. Field methods of chemical analysis. 2nd ed. Gosgeolizdat.
11. Collection. 1957. Chemical analysis methods for minerals. No. 3. Gosgeoltekhizdat. Moscow.
12. SOKOLOV, D.F. 1940. The determination of organically bound phosphorus in soil. Pochvovedeniye, No. 3.
13. KHEYFETS, D.M. 1954. Methods for the determination of phosphorus in the soil. In: Agrokhimicheskiye metody issledovaniya pochv.
14. SHCHERBO, D.P. 1948. Colorimetric determination of phosphorus in the water of a phosphorus-vanadium-molybdenum complex. Byul. VIMS. No. 9(69).
15. JACKSON, M.L. 1958. Soil chemical analysis. In English.

CHRONICLE

ACADEMICIAN VLADIMIR NIKOLAYEVICH SUKACHEV

V. V. Dokuchayev Soil Institute, All-Union Society of Soil Scientists, and Pochvovedeniye Editorial Board

Dear Vladimir Nikolayevich:

On your 80th birthday and for your more than 60 years of scientific research, teaching, and public activity, the All-Union Society of Soil Scientists, of which you are an honored member, the editorial board of Pochvovedeniye, and the V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR, greet you and sincerely wish you good health and many more years of creative work in behalf of our motherland.

You have written glorious pages in the history of our biological and geographical sciences. Your research in the fields of geography, geobotany, forestry, bog science, and Quaternary history of the development of vegetation has greatly helped to advance soil science as a whole and its individual branches, particularly forest soil science. More than one generation of outstanding Soviet geobotanists, geographers, foresters, and soil scientists have been reared in your works.

It is a special source of gratification to note that throughout your scientific life you have been a consistent follower of Dokuchayev. For more than half a century you have successfully enlarged on his ideas and striven to the best of your ability to apply them to practical problems.

Work done under your direction in the semi-desert Caspian steppes by the Dzhanibek and Arshan'-Zel'men field stations, and at the Derzhinskaya experimental station founded by V. V. Dokuchayev is a graphic illustration of the broad and inexhausted possibilities of transforming the arid soils of the Soviet Union.

For this immensely useful scientific achievement you have been given the highest award—the V. V. Dokuchayev Gold Medal.

And now you are continuing with your characteristic diligence to develop Dokuchayev's ideas regarding the creation of a science to study not the individual bodies and phenomena of nature, but the connections between them and the regular relationships existing between the plant, animal, and mineral kingdoms on one hand and with man on the other.

These ideas have found expression in your theory of the biogeocoenosis as a natural phenomenon in which all of its components are mutually related and interdependent. The naturally conflicting interrelations of the biotic and abiotic components are the source of movement and development of biogeocoenoses. You ascribe particular significance to the soil as the source of water and nutrition of their living population. You believe that the mutual achievements of biogeocoenologists and soil scientists will promote their development and thoroughly elucidate the various kinds of exchange of matter and energy between all the components of the biogeocoenoses and between them and the environment.

This new, biogeocoenotic emphasis requires the cooperation of biologists, soil scientists, and geographers for further progress in understanding the developmental patterns of natural bodies and phenomena in line with the modern demands of science and practical work and in using this knowledge to devise ways of transforming nature in the interests of more efficient use of its resources.

In this, as in all your multifaceted scientific and public activities, we wish you once again, dear Vladimir Nikolayevich, success, health, and long life.

ACADEMICIAN IVAN VLADIMIROVICH TYURIN

V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR, All-Union Society of Soil Scientists, and Pochvovedeniye Editorial Board

Dear Ivan Vladimirovich:

The staff of the V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR, soil scientists of the Soviet Union, together with the All-Union Society of Soil Scientists affiliated with the Academy of Sciences, USSR, and editors of Pochvovedeniye offer their congratulations on the high scientific award, the V. V. Dokuchayev Gold Medal, conferred on you by the Presidium of the Academy of Sciences, USSR.

This high honor has been awarded not only for your personal contribution to the development of Soviet soil science covering 40 years of inexhaustible labor in the fields of soil genesis and geography, humus formation and soil chemistry, elaboration of methods of chemical description of soil, training soil scientists and foresters, but also for your extensive scientific administrative activity and popularization of Soviet soil science abroad.

Your role in advancing Soviet soil science is immense. Your research on organic matter and the process of humus formation represents something new in developing the biological approach to the study of soils, an area in which

you are universally acknowledged an authority. No less significant is your work on soil genesis and geography of the forest-steppe zone. This work remains the foundation for further investigations of the genesis, geography, and agromonomical characteristics of soils in this remarkable zone which finds no parallels in other countries.

In your work you have steadily and consistently developed and are still developing the ideas of the great founder and creator of USSR soil science, Professor V. V. Dokuchayev, and many of his outstanding followers, notably Academician V. V. Vil'yams.

Experiencing deep satisfaction and seeing in your winning the highest of awards for a soil scientist recognition both of your personal services and of the progress made by Soviet soil scientists working under your tireless guidance, all soil scientists wish you further creative achievements and good health in your highly valuable efforts to promote soil science in the Soviet Union.

CONFERENCE ON SITE QUALITY AND CHEMICAL CHARACTERISTICS OF USSR SOILS

YE. ANDREYEVA

A conference was held from December 7 to 12, 1959 in the V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR on the problems relating to the site quality and chemical characteristics of USSR soils. The conference was organized by the Division of Biological Sciences, Academy of Sciences, USSR, Agricultural Division of VASKhNIL, and the V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR.

Some 318 persons took part in the conference representing about 100 organizations. These included 194 members of institutes of the Academy of Sciences and its republic branches, VASKhNIL, and institutes of republic academies of agricultural sciences. A total of 80 workers in the Ministry of Agriculture, Ministry of Sovkhozes, oblast' agricultural administrations, and experimental stations as well as 44 representatives of agricultural schools, universities, and training schools were also in attendance. Sixty-two papers were read, including 15 on site quality of soils.

In his welcoming remarks Academician I. V. Yurin urged that due attention be accorded to problems bearing on the chemical characteristics and site quality of USSR soils possessing practical significance for agriculture.

A. N. Panfilov presented a critical survey of studies on site quality of soil, pointing out the importance of finishing the large-scale soil investigations now going on throughout the country so that kolkhozes and sovkhozes can utilize the data in their daily work and base local site quality index on them.

S. S. Sobolev set forth the results of the Soil Institute's efforts to prepare an all-union site quality index of soil and the fundamental principles that should govern the preparation of the national, oblast', and kray site quality index.

S. D. Cheremushkin reported on methods of making economic appraisals of agricultural lands.

The conference heard and discussed reports describing experiments on site quality of soils in Tomsk Oblast', (N. F. Tyumentsev); Lower and Northern Caucasus, (F. Ya. Gavrilov); the northwestern part of the nonchernozem zone, (N. L. Blagovidov); the Latvian, Lithuanian, and Estonian SSR, (K. K. Brivkalm, I. I.

Baytekunas, and A. Lillema); the southern part of the Baykal region, (I. N. Rynks); the dry-farming soils of Stalingrad Oblast', (V. F. Shubin); Belorussian SSR, (A. T. Medvedev); Moldavian SSR, (V. A. Fil'kov); Azerbaydzhan, (V. R. Volobuyev); Bashkir ASSR, (S. N. Taychinov); on the principles of site quality of natural and reclaimed bog soils, (I. N. Skrynnikova); etc. The papers were followed by a broad discussion of methods of site quality of soils.

Methods and the role of large-scale soil maps in economic appraisals were dealt with in the reports of I. G. Vazhenin, N. K. Krupskiy, and Yu. A. Liverovski, which stimulated a lively discussion.

A. V. Sokolov's paper took up some questions involved in studying the chemical properties of soils and use of fertilizers in the USSR. There was also a statement of basic considerations in organizing a USSR soil agricultural chemical service. The statement was approved by the conference and incorporated in a resolution.

Ya. V. Peyve reported on trace elements in USSR soils and the effectiveness of trace fertilizers.

The comprehensive reports of A. P. Zemite, I. S. Stanislavichute, and O. Khallik dealt with the chemical characteristics of the main soil groups of Latvia, Lithuania, and Estonia. A. V. Mizerov and V. A. Bukhman read papers on agricultural chemical research in Kareliya. N. P. Karpinskiy and A. G. Trutnev discussed the chemical characteristics of the sod-podzolic soils of European USSR. Data on the chemical characteristics of soils in the Central Urals, Tatar ASSR, and forest-steppe zone of Bashkiriya were presented by M. P. Petukhov, M. F. Kurochkin, and M. N. Burangulova. Of interest were reports on the work performed in the agricultural laboratory of the Bol'shevik sovkhoz (L. I. Korableva) and in the Veviy laboratory. G. B. Babayan gave an account of the work and plans of the Agricultural Laboratory of the Academy of Sciences, Armenian SSR concerning the chemical characteristics of soils. Rich factual material on chemical characteristics and effectiveness of fertilizers on a variety of chernozem soils was included in the papers of P. G. Aderikhin, M. B. Gilis, V. A. Frantesson, P. Ye. Prostakov, and A. I. Simakin. The chemical characteristics of some Moldavian soils were

discussed by I.I. Kanivets and Ye.I. Tukałova.

A joint report by A.M. Grinchenko and Din Zhuy-sin described the chemical characteristics of dark chestnut soils in the southern part of the UkSSR. The chemical characteristics of some Central and Eastern Siberian soils and various soils in the Kanskaya forest steppe of Krasnoyarsk kray were discussed by O.V. Makeyev and P.I. Krupkin. There were also communications on Amur Oblast' (V.T. Kurkayev), and Sakhalin Island (A.M. Ivlev) soils and their agricultural chemical characteristics. K.I. Imangaziyeu read a paper on the agricultural chemical characteristics of Kazakh SSR soils, Ya.F. Dubovnik on central Tyan'-Shan' soils, and R.K. Guseynov on Azerbaydzhan soils. I.N. Chumachenko and I.M. Lipkind reported on the effectiveness of phosphorous fertilizers on some Tadzhikistan soils. Many of the reports raised questions on methods of agricultural chemical research. Z.I. Zhurbitskiy evaluated methods of determining available nutrients in soil.

The conference concluded by unanimously adopting a resolution taking cognizance of the extensive and exceedingly valuable data presented in the reports. These throw light on the nature and scope of USSR studies on site quality and agricultural chemical characteristics of soils and outline future research with due regard for the work described in the reports.

We must now concentrate on the preparation of oblast', kray, republic, and zonal (provincial) site quality scales.

We must intensify our research on the agricultural chemical characteristics and site quality of soils with the V.V. Dokuchayev Soil Institute, Academy of Sciences, USSR held responsible for guidance and coordination. The conference urged that the All-Union Society of Soil Scientists and Scientific and Engineering Society of Agriculture and Silviculture and their local branches take an active part in the work.

The conference approved the work of the V.V. Dokuchayev Institute, Academy of Sciences, USSR in preparing an all-union soil quality scale and the great efforts made by the Soil Institute, Academy of Sciences, VIUA, and Soil Institute, UkSSR to organize and carry out large-scale soil investigations leading to the elaboration of convenient measures for more effective utilization of the land. The conference also noted the extensive work on soil site quality performed by Rostov and Tomsk Universities, Stalingrad and Gorkiy Agricultural Institutes, and the Baltic republic institutes of agriculture and economies.

The conference recommends the organization of short oblast', kray, and inter-oblast' courses to train soil scientists, agronomists, and soil chemists for large-scale soil mapping and courses designed to familiarize them with up-to-date methods of investigating soils. The conference deems it necessary that the curricula of agricultural colleges and soil departments of universities include in their courses in soil science and agricultural chemistry sections dealing with methods of compiling soil, soil erosion, and soil chemical maps and with problems of site quality of soil.

REVIEW

SYMPOSIUM IN THE UNITED STATES ON SOIL GENESIS

M. FRIDLAND

In November 1957 the fifth committee of the American Society of Soil Scientists held a symposium in Atlanta on the subject "Modern Ideas of Soil Genesis." The published papers (1959) are a good idea of current American thinking on soil genesis.

The first paper, presented by the head of the classification section of the United States Soil Survey, Roy Simonson (1), is an attempt at a generalized theory of soil genesis. The other four papers examine the current status of knowledge regarding the genesis of major soil groups—gray-brown podzolic (2), podzols (3), and yellow podzolic (4), and low humic podzols (5).

Simonson begins by pointing out that V. V. Dokuchayev and his co-workers were the first to conceive of soil as a natural body, of soil formation as a process not to be identified with weathering, of the factors of soil formation, and of the soil profile as formed from genetically related horizons. However, Simonson entitles his paper above "Past Concepts of Soil." This is easily justified because Dokuchayev's ideas are the foundation of soil science all over the world. It lends special interest to the next part of his paper entitled "Modern Concepts of Soil." How does the modern concept differ from the old concept? Simonson stresses that soil is a three-dimensional body separate from the air, usually not sharply distinct from neighboring rocks, and gradually turning into rock. He states that a given soil group can form several discrete "soil bodies" under certain environmental conditions. All soils have a series of common characteristics. They have solid, liquid, and gaseous phases and contain minerals, organic matter, water, and air. They all have a finite type of profile and occupy space. This set of views comprising the "modern concept of soil" adds nothing of importance to Dokuchayev's teaching nor does it outmode any of his views.

Simonson's views are set forth in the following section entitled "Steps and Processes in Soil Genesis." The author suggests dividing soil formation into two steps—accumulation of soil-forming material and "horizon differentiation in the soil." Emphasizing the arbitrariness of the division and difficulty in distinguishing the two steps, Simonson nevertheless considers it useful. He points out that Dokuchayev broke the

soil-formation process down into weathering and activity of organisms. However, it is impossible to agree that "accumulation of soil-forming material" is the first step in soil formation and that his analogies are apt. If the accumulation of parent material is regarded as a process of rock weathering rather than as a formation, then the distinguishing of this step from that of profile formation is unsound. The analogies cited merely strengthen our doubts because Dokuchayev considered weathering one of the aspects of soil formation proper, i.e., profile formation.

Simonson distinguishes four principal kinds of changes taking place in all soils: addition, removal, transfer, and transformation. These four changes apply to all the constituents of the soil and they, in turn, determine the formation of the profile. This position is unassailable, for it is one of the major axioms of genetic soil formation, a logical extension of the very concept of soil. However, the four changes are not exclusive with soil formation; they are equally characteristic of many other natural processes, e.g., plutonic metamorphism, transformations in natural waters, etc. Greater precision in describing the nature of the substances involved in soil formation as well as the processes and forms in which they move about and accumulate will give specific soil-genetic content to this definition.

Simonson justly notes that the four changes do not always result in profile differentiation. They may at times inhibit the process (activity of soil fauna, biological accumulation of vegetation, etc.).

Simonson uses the transformation of organic matter as an illustration. He points out that in the early stages of soil formation the addition of organic matter exceeds the loss, thereby creating the humus horizon. Loss then balances addition and the amount of organic matter becomes constant, although varying for different groups of soils because the balance between addition and loss is equalized for each of them at different levels in the soil. Since organic residues are added every year while the amount of organic matter does not vary, it is evident that the processes of transformation and decomposition proceed rapidly. However, the soil also has stable organic matter, as proved by the radio-carbon method which shows the age of organic matter in the lower portion of the humus horizon of uncultivated soils in the midwestern part of the

United States. These soils were formed under grass 210 to 410 years ago. The process of transferring organic matter down the profile is clearly visible in several podzolic soils and solodized solonchets. Numerous krotovinas and passageways of earthworms testify to the role of soil organisms in the transformation and transfer of organic matter.

In the last section ("Combination of Processes") Simonson stresses that his views do not constitute a rejection of the ideas of the past but merely modify and reformulate them with different emphasis. For example, he mentions the need of investigating complexes of processes both facilitating and hindering the differentiation of horizons and of studying the balance between processes in different combinations. The author believes that shifts in the balance of the effects of different processes are more responsible for differentiating soil than the action of clearly distinct genetic processes. These ideas, he feels, explain more satisfactorily the existence of soils as a continuity on the earth and the absence of sharp boundaries between different soils.

We accept the first two notions, which do not change our theories of soil genesis. They are clearly linked to our well established investigations of individual aspects and processes of soil formation (the so-called "elementary soil-forming processes"). It is pertinent to recall here the older work of the Germans on the mobility of organic matter, the numerous studies of Russian and Soviet authors on the decomposition of plant residues, weathering of individual rocks and minerals, absorption by plants of substances from the soil and return of these substances to the soil, etc. Soil investigations make use of the method of balances although, unfortunately, not as widely as they should.

Simonson's third point—"The differences in soils are caused more by shifts in the balance of combinations of processes than by the action of clearly distinct genetic processes" (p. 155)—is debatable. Our doubts are based chiefly on the tremendous variety of soil-forming processes and on the existence of innumerable qualitative differences in soil. Let us consider the entry of organic matter into soil, the example used by Simonson. The amount can be measured, e.g., in kilograms per hectare a year. But is this a comprehensive characteristic? Hardly. Most of it enters directly via the surface (in forests) or indirectly (in steppes); the composition of the residues differs as do the circumstances under which they reach the soil. Thus, when we compare the different groups and even subgroups of soils we see clearly differentiated genetic processes (of course, along with several processes common to several groups or subgroups). To give preference to the balance of combinations of processes and to consider the role of differences in genetic processes secondary is to relegate the task of elucidating the qualitative characteristics of soil-forming processes in different soils to the background. The fact is that ascertaining these characteristics is the major task of genetic soil science. Here too we cannot fail to note the close connection between quantity and quality.

As mentioned previously, the author regards

the soil as a continuity. This is acceptable provided that the statement is expanded to read: the soil is both a continuity and a discontinuity, continuity in the sense that soils in general, like the pedosphere, and discontinuity in the sense of qualitatively different soils. If we regard the soil solely as a continuity, we must disregard the qualitative differences in various soils, processes taking place therein, and the reasons for the origin of soil boundaries. If we regard it only as a discontinuity, we fail to see the unity of soils, numerous transitions into one another, interrelations, evolutionary and ecological series.

We must bring up a matter not directly mentioned by the author, but closely connected with what he said, i.e., the most probable and most widespread combinations of processes. It logically follows from his remarks that all processes have equal significance and are equally probable, i.e., any soil has an equal possibility of developing. In practice, however, this is not so. Some soils are very common and little changed from one place to another, whereas other soils have scant distribution and rapidly give way to other soils. We may thus speak about more or less probable combinations of elementary processes, about the existence of some highly common complexes of processes — qualitative unities responsible for the development of soils and creating the basis of zonal soils. It is these complexes of elementary soil-forming processes which create zonal soil groups. They have been called by K. D. Glinka, A. A. Rode, and others the "chernozem soil-forming process," "podzol-forming process," etc. It seems to us that a study of the interrelations and interdependence of elementary processes has in no way lost its importance and that the solution of these problems is just as crucial to the development of genetic soil science as a thorough investigation of individual elementary soil-forming processes.

The other four papers read at the symposium are highly interesting. They set forth the results of research on the formation of major genetic groups of soils.

Thorp, Cady, and Gamble (2) investigated a typical profile of gray-brown podzolic soils (Miami series) found in Lewis Woods near Williamsburg, Indiana. These soils resemble the sod-podzolic and podzolized brown forest soils of Soviet classifications. The authors' studies of texture and mineralogical composition and micromorphological structure of this profile and models of soil processes led them to the following main conclusions:

1. Profile differentiation by texture is caused by movement of clay fractions in suspensions. This movement occurs chiefly at the end of summer and in the fall when rain soaks the dry and cracked soil. Observations of the moisture regime of soils have shown that the rain normally does not penetrate beyond the clay-rich B_2 horizon where it is checked by decreased water permeability and absorption by roots. The deeper leaching of winter and fall may move the clay even below the B_2 horizon, but the amount involved is slight.

2. Micromorphological observations have revealed a thin clay film on fragments of limestone and dolomite abundant in soil-forming parent material. This does not answer the

question of whether clay suspensions can move in the presence of carbonates, although it does suggest the possibility of movement very close to them.

3. Experiments with the leaching of intact soil columns by water extracts from the leaves of sugar maple and by distilled water have shown that clay moves in either case, but a leaf extract makes a greater quantity of clay particles mobile than does distilled water.

4. Clay formed *in situ* as a result of weathering constitutes less than half the total clay content of B horizon and a substantial part of the clay in the A and C horizons.

Stobbe and Wright (3) discussed the modern concept of podzol formation. They emphasize that there are differences in interpreting the terms "podzol" and "podzolic" and go on to describe a typical podzol profile. The profile consists of A₀ horizon (litter), light-colored illuvial A₂ horizon (relatively poorer in sesquioxides than in silica), darker colored illuvial horizon (where sesquioxides and organic matter accumulate).

The soil profile is acid, the adsorption complex unsaturated. The accumulation of clay particles in B horizon typical of podzolic soils lacking in podzols and here the content of clay particles in A₂ horizon is sometimes greater than in B. Podzols develop under those climatic and biological conditions in which acid products of decaying organic matter form (this occurs more readily in a damp, cool climate under forest and heather vegetation) when internal drainage is normal.

It is not clear why soils containing more clay particles in A₂ horizon than in B are in this group. They are probably sandy varieties in which Soviet investigators have sometimes noted a similar phenomenon. The authors suggest narrowing the term "process of podzol formation" to include only those reactions caused by the movement and accumulation of sesquioxides and organic matter.

The development of podzol formation requires leaching of salts and adsorbed bases which is responsible for the non-saturation of the adsorption complex. The rate of the process depends on the composition and properties of the soil. Non-saturation is followed by dispersion and transfer of clay to the lower part of the profile, resulting in the formation of a clay-rich horizon. The authors propose that this process be regarded not as the first step in podzol formation but as a "preprocess" which makes podzol formation possible and at the same time extends the accumulation of clay in the illuvial horizons of many podzols (in the view of the authors). It is worth noting that this opinion was expressed by N. Chernescu back in 1937 at the meeting of the fifth committee of the International Society of Soil Scientists in Vienna. This was probably unknown to the authors of the paper.

They then take up the mechanism by which the sesquioxides move in the soil. Noting that compounds of trivalent iron dissolve only when the pH is below 3.5, very rarely encountered in soil, they admit that iron moves in free form only

under reduced conditions in bivalent form, which is characterized by solubility when the reaction is less acid.

The movement of sesquioxides as negative sols protected by humus is considered possible by the authors who believe that it is necessary to study this process, particularly the mechanism by which these sols precipitate under the influence of bivalent cations in the lower horizons of the soil profile.

Mattson's theory of movement and precipitation of sesquioxides (isoelectric potentials), according to the authors, is not applicable to podzols because they do not have the high pH gradients required for the movement and precipitation of sesquioxides called for by the theory.

The authors attach the highest importance to the movement of sesquioxides to soluble organic mineral complexes, stressing that the function of organic acids in podzol formation as the solvents of sesquioxides was elucidated in the works of Russian scientists (Rode, Kononova, Aleksandrova, and Yarkov). The authors say that various forms of soluble organic mineral compounds may arise (salts of organic acids, complexes, chelates). They point out that compounds of bivalent forms of iron are more mobile than the trivalent forms. Examining the processes by which these compounds are precipitated, the authors call attention to the activity of microorganisms, oxidation processes, and reaction of the medium.

The processes of infiltration of solutions or colloidal humus suspensions, quite marked after rain, take place in humus podzols containing about 10%-20% humus in the illuvial horizon. Some of the humus escapes from the profile, some of it is trapped in the B horizon whose permeability is low as a result of the eluviation processes developing earlier.

The report unfortunately makes no mention of several important aspects of podzol formation (even in the narrow sense of the word as used by the authors), for example, sources of mobile sesquioxides, degree of stability of clay minerals, interrelation of texture of the illuvial horizon and soil-forming parent material, conditions needed for the processes of clay movement to give way to the processes of movement of organic matter and sesquioxides, etc.

McCaleb (4) discussed the genesis of red-yellow podzolic soils and compared them with the reddish-brown lateritic soils. A typical profile of red-yellow podzolic soils, according to McCaleb, consists of A horizon changing into a finer-texture and more brightly colored B horizon containing appreciable amounts of clay skin most developed on the vertical sides of structural units. The B₁ horizon is followed by the B₂ horizon, the most brightly colored horizon in the profile and characterized by larger and more stable structural units and with most clearly pronounced clay skins. The B₃ horizon is mottled, its structural units not distinctly isolated, and its clay content higher than in the preceding horizon; the clay skins are less pronounced and the formation of clay proceeds *in situ*. The C horizon is formed by strongly

weathered material which has retained the structure of the original rock and its clay content is always less than in B horizon; clay films are rare and associated with roots and cracks, the basic mass of clay having formed *in situ*. In horizon B of reddish-brown lateritic and red-yellow podzolic soils it has been shown that the transition from reddish-brown lateritic through red podzolic and red-yellow podzolic soils to yellow podzolic soils is due to the change of soil-forming parent material from basic through neutral to acid. The A₂ horizon starts this way and subsequently enlarges; the thickness of the B₂ horizon in all the profiles has proved to be quite stable. The degree of weathering of the original rock, on the other hand, decreases. Research on weathering has shown that the various minerals behave in different ways. The mottled color, according to the author, is due to the fact that the main color resulting from the rock weathering *in situ* has been mingled with the colors of the horizons below after the clay material moves from there along the roots and cracks. Iron oxides cover all the soil particles.

Analysis of the red, red-yellow, and yellow podzolic soils has revealed a distinct increase in clay content, exchangeable bases, and free iron oxides in the B horizon. At the same time this horizon is the least acid of all. Distribution of clay through the profile is due to weathering and the movement of clay from top to bottom. The lower clay content of the A horizon is the result of more rapid development there of weathering processes and greater number of pores and cracks, which facilitate the escape of its clay. The author has no data confirming the decomposition of clay in the top horizons of red-yellow podzolic soils. Simonson, who had earlier studied the genesis of these soils, considered this decomposition to be the consequence of the processes taking place therein.

It is noteworthy that McCaleb does not attribute the mottled color of the B horizon to stagnant water and partial gleying of the horizon, as stated in the literature. Exchangeable Al and free Al and Fe oxides, according to McCaleb, are found in horizons with still unweathered minerals, the sources of these substances. They are constantly replenished wherever there is active weathering.

McCaleb concludes by comparing the genesis of red-yellow and gray-brown podzolic soils. The only significant difference is the degree of expression of the corresponding horizons, which he ascribes to the difference in age of the soils. The older red-yellow podzolic soils have more weathered primary minerals, greater content and differentiation by profile of clay particles, greater profile development, and a more acid reaction.

However, the author might well have considered the difference in biological and climatic conditions under which they form (subtropical for red-yellow podzolic soils and temperate zone forest for gray-brown podzolic soils). A study of their typical representatives and transitional formations (in connection with the conditions under which they are created) would have been very helpful in establishing the correlations between these two major American soil

groups. This was outside the author's scope as were the differences in tropical and subtropical soils related to biological and climatic factors.

McCaleb compares red-yellow podzolic soils with lateritic soils, something rarely done in the reports of American soil scientists.

The last paper at the symposium, "Characteristics and Genesis of Low Humic Latosols," was presented by Sherman and Alexander (5). These soils develop on crystalline bedrock under semi-arid and semi-humid tropical conditions with a distinct dry season that is responsible for dormancy in natural vegetation. Unfortunately, the authors do not describe the vegetation, thus making it difficult to understand the genesis of the soils in question. The predominance of kaolinite in the clay fraction is characteristic of low humic latosols. The content of free iron oxides and, not infrequently, of aluminum is quite high. Certain groups of these soils containing montmorillonite are transitional to the dark magnesian clays (tropical chernozems). They are marked by low ratio of carbon to nitrogen in organic matter (less than 9) and the absence of any clay movement through the profile. They have a red coloration and fairly homogeneous profile structure in which the lower horizons differ from the upper ones in having a lighter coloration and coarser structure. The ratio of silica to sesquioxides in the clay fraction of different soils in this group amounts to 1.1-1.7 and to 1.7-2.3 in the soil. The total chemical composition of soils remains invariable; the exchange capacity ranges from 10 to 3 meq/100 g while base saturation comes to 30%-100%. The reaction is neutral, sometimes weakly acid in the lower part of the profile. The structure of the top horizon in the drier representatives of the group is platy, but granular in the moister representatives; in B horizon it changes from large prismatic to medium blocky. The structural units are characterized by very high stability. The soil possesses high water permeability (75 mm/hr), which causes a rapid loss of weathering products that promotes the formation of kaolinite.

It seems to us that this group of soils can develop not only on crystalline bedrock, as Sherman and Alexander write, but also on many other deposits found under suitable biological and climatic conditions. This has been confirmed by a number of Indian, African, and South American soil scientists.

An examination of the material shows that the low humic latosols include two groups of soils in the Soviet classification—the red soils of the high-grass savannahs and red-brown soils developed in more arid areas—as shown by differences in structure and conditions of formation (from 250 to 2000 mm of precipitation annually, from none to six months a year with over 125 mm precipitation a month). Hence, these latosols constitute a wider group than the corresponding soils in the Soviet classification.

In concluding our survey of the symposium we want to stress that those conferences which deal with only a few major scientific problems each treated in a separate paper, are one of the most productive types of scientific discussions. The materials of the symposium are of great

SOIL GENESIS SYMPOSIUM

interest to all specialists in the field of soil genesis. Our only regret is that the American Society of Soil Scientists has not seen fit to publish the discussion provoked by the reports and thus enable others to gain familiarity with the views and research findings of a larger number of American soil scientists.

BIBLIOGRAPHY

1. SIMONSON, ROY, W. 1959. Outline of a generalized theory of soil genesis. Soil Sci. Soc. of America. Proc. Vol. 23, No. 2.
2. THORP, J., J. G. CADY and E. E. GAMBLE. Genesis of Miami Silt loam. Ibid.
3. STOBBE, P. C. and J. R. WRIGHT. Modern concepts of the genesis of podzols. Ibid.
4. McCALEB, S. B. The genesis of the red-yellow podzolic soils. Ibid.
5. SHERMAN, I. D. and L. T. ALEXANDER. Characteristics and genesis of low humic latosols. Ibid.

BIBLIOGRAPHY

FACTORS OF SOIL FORMATION, GENESIS AND THE GEOGRAPHY OF SOILS

1. Agricultural climatic handbook for the Karelian ASSR. 1959. Leningrad, Gidrometeoizdat. 184 pp., with illustr. and maps.
2. Agricultural climatic handbook for the Kirovograd Region. 1959. Leningrad, Gidrometeoizdat. 86 pp., with illustr. and maps.
3. Agricultural climatic handbook for the Leningrad Region. 1959. Leningrad, Gidrometeoizdat. 176 pp., with drawings and maps. Bibliog. pp. 142-143.
4. Agricultural climatic handbook for the Mordovian ASSR. Leningrad, Gidrometeoizdat. 116 pp., with schemes and maps. Bibliog. 53 refs.
5. Agricultural climatic handbook for the Nikolayev Region. 1959. Leningrad, Gidrometeoizdat. 104 pp., with maps. Bibliog. pp. 101-102.
6. AKSENT'YEVA, G.M. 1959. Certain characteristics of soils in the Volga-Akhtuba flood plain after embanking. Tr. Stalingradsk. s.-kh. in-ta. 11(1):179-184.
7. BOYARKIN, V.M. 1958. The flood plain of the Angara River. Tr. Irkutsk. gos. un-ta. Vol. 24, ser. geogr. No. 1:3-19 with illustr.
8. BOYARKIN, V.M. and A.D. IVANOV. Sands of the Angara River valley. Ibid. pp. 21-41, with illustr.
9. Problems on the physiography of the USSR. 1959. (Collection of articles). Edited by N. A. Gvozdetskiy and M. A. Glazovskaya. Moscow, Izd-vo Mosk. un-ta. 185 pp., with illustr. and maps.
10. GAVRILYUK, F.YA. 1959. Qualitative evaluation of soils and land use. S. kh. Sev. Kavkaza. No. 10:44-46.
11. GARKUSHA, I.F. 1959. Soils of the tundra zone. Lectures for correspondence students of agricultural faculties. (Belorussian Academy of Agriculture). Gorki. 13 pp.
12. DVORNIKOVA, L.L. 1959. Characteristics of plowed soils in the northwestern part of the Vologda Region. Vestn. Leningr. un-ta. No. 24. Ser. geol. i geogr. No. 4: 142-153. Bibliog. 5 refs.
13. DOBROVOL'SKIY, G.V. and A.P. LOBUTEV. 1959. Soils of the Klyaz'ma flood plain and their agricultural utilization. Nauchn. dokl. vyssh. shkoly. Biol. nauki. No. 4: 175-181, with maps. Bibliog. 8 refs.
14. ZOLOTAREV, A.G. 1958. Certain problems of the geomorphology and palaeogeography of the central part of the central Siberian plateau. Tr. Irkutsk. gos. un-ta. Vol. 24. Ser. geogr. No. 1:43, 56, with illustr. Bibliog. 14 refs.
15. ZOL'NIKOV, V.G. 1959. Development of the law of zonality in nature. (Devoted to the 60th anniversary of the discovery of the law of zonality in nature by V.V. Dokuchaev). Nauchn. dokl. vyssh. shkoly. Biol. nauki. No. 4:168-174. Bibliog. pp. 173-174.
16. KANONNIKOV, A.M. 1959. System of taxonomic units in physiographic classification. Uchen. zap. (Krasnodarskiy ped. in-t). No. 24:198-228, with maps. Bibliog. 26 refs.
17. KRYLOV, YU.V. 1959. Glacial formation of loess in Tadzhikistan. Dokl. Akad. Nauk Tadzh. SSR. 2(3):29-33. Bibliog. p. 32. Summary in Tadzhik.
18. KRYL'KOV, YU.V. 1959. Subsidence of loess and other fine earth materials. Dokl. Akad. Nauk Tadzh. SSR. 2(3):25-29. Summary in Tadzhik.
19. LEVANDOVSKIY, P.A. 1959. Physiographic characteristics of the Black Sea shore from Anapa to Novorossiysk. Uchen. zap. (Krasnodarskiy ped. in-t). No. 24:235-254. Bibliog. 6 refs.
20. LEONT'YEV, O.K., M.YE. BAKHTINA, and T.A. DOBRYNINA. 1959. Investigation of deposits in the coastal zone of the Northwestern Caspian Sea. Tr. Okeanograf. komissii (Akad. Nauk SSSR). No. 4:18-30, with maps. Bibliog. 9 refs.
21. PECHERIN, A.I. 1959. Problem of the geo-

BIBLIOGRAPHY

- morphology of the Lower Amur lowland. Amurskiy sbornik. 1:121-125.
2. MAKKAVEYEV, A.A. 1959. Quaternary deposits of the Pripyat' Poles'ye. Tr. Vsesoyuzn. n.-i. in-ta gidrogeol. i inzh. geologii. Collection No. 18:110-133 with maps. Bibliog. pp. 131-133.
3. Materials on the Quaternary geology and geomorphology of the USSR. 1959. (Collection of articles). (Materialy Vsesoyuzhn. n.-i. geol. in-ta VSEGEI. No. 2. Chetvertichn. geol. i geomorfologiya). Leningrad, Gostoprekhiizdat. Leningr. otd. 198 pp., with illustr. and maps.
4. ORLOVSKIY, N.V. 1959. Classification and grouping of soils according to their agricultural productivity in the Altay Mountains Autonomous Region. Krayeved. zapiski (Alt. krayev. muzey). No. 2:24-62. Bibliog. 34 refs.
5. POPAZOV, D.I. 1959. Factors of soil formation. Izv. Timiryazevskoy s.-kh. akad. No. 6:77-94. Bibliog. pp. 93-94.
6. Nature in the Amur Region. 1959. Blagoveshchensk. Amurskoye kn. izd. 311 pp., with illustr. and maps.
7. SELIVANOV, YE. I. 1959. Problem of the ancient glaciation of Central Asia. Izv. Vsesoyuzn. geogr. o-va. 91(6):491-500, with maps. Bibliog. 20 refs.
8. SMIRNOV, L.YE. 1959. Use of aerial photographs in the study and forecasting of flash floods. Vestn. Leningr. un-ta. No. 24. Ser. geol. i geogr. No. 4:153-158.
9. SOLYANIK, G.M. 1959. Characteristics of soils of steppe depressions. Uchen. zap. (Krasnodarskiy ped. in-t). No.24: 144-150. Bibliog. 8 refs.
10. TREPETTSOV, YE.V. 1959. Loess karst in the vicinity of Barnaul. Krayeved. zapiski (Alt. krayev. muzey). No. 2: 63-73.
11. USPANOV, U.U. 1958. Major soil-climate zones and land resources of Kazakhstan. Vestn. s.-kh. nauki (Alma-Ata). No.1-2: 28-31.
12. SHEVCHENKO, N.G. 1959. Fresh waters of a sandy desert (as exemplified by the Western Kara-Kum). Tr. Vsesoyuzn. n.-i. in-ta gidrogeol. i. inzh. geologii. Collection No. 18:36-41, with maps.
13. ARNEMAN, H.F. et al. 1958. Physical, chemical and mineralogical properties of related Minnesota prairie soils. Minneapolis. 47 p. Bibliog. pp. 35-37.
14. BADEN, W. and H. SEGEBERG. 1949. Untersuchungen über die landwirtschaftlichen Nutzungsmöglichkeiten der Moorgebiete im Gotteskoog. Wasser und Boden. 2(6):177-189.
15. BAHERJEE, S. 1959. Some aspects of salt-affected soils of West Bengal. Soil Sci. 88(1):45-50.
16. BLACKBURN, G. and T.I. LESLIC. 1958. The characteristics and origins of soils in the Coletaine district, Victoria. Melbourne. 47 pp.
17. BOULAIN, J. 1959. Sols marrons jeunes et sols tirsifies jeunes. Bull. Assoc. franc. etude sol., No. 2:52-57.
18. CHATTERJEE, S.P. et al. 1957. Pedogenesis in West Bengal. 2. Geogr. Rev. India, 19(4):1-12.
19. COPPENET, M. 1959. Les caracteres des sols granitiques de Bretagne. Bull. Assoc. franc etude sol., No. 1:1-25.
20. COWIE, J.D. and B.A.J. SMITH. 1958. Soils and agricultures of Oroua Downs, Talkorea and Glen Oroua districts, Manawatu County. — Cowie J.D. Soils and erosion. Smith, B.A.J. Agricultural notes. Wellington, New Zealand. 56 pp.
21. Desert research. 1953. Proceedings International symposium held in Jerusalem, May 7-14 1952. 644 pp.
22. DIJK, D.C. VAN. 1958. Principles of soil distribution in the Griffith-Yenda district, New South Wales. Melbourne, 24 pp. (Commonwealth scient. and ind. res. organization, Australia. Soil publ. No.11).
23. FANNING, C.D. and F. GRAY. 1959. Characterization and genetic study of a Dennis and a Parsons soil. Soil Sci. Soc. America Proc. 23(4):321-324.
24. KAMOSHITA, Y. 1958. Soils in Japan. With general map of soil types in Japan 1:800,000. Tokyo. 58 pp.
25. KOEHNLEIN, J. and E. SCHLICHTING. 1959. Eigenschaften und Nutzung kultivierter Heidepodsole in Nordwestdeutschland. Z. Pflanzenernähr., Düng., Bodenkunde. 84(1-3):296-308. Bibliog. pp. 307-308.
26. KUNDEL, P. 1959. Zur Kenntnis der Rasenpodsole und grauen Waldböden Mittelrusslands im Vergleich mit den sollessives des westlichen Europas. Z. Pflanzenernähr., Düng., Bodenkunde 86(131):16-36.
27. LAG, J. 1958. Preliminary report on calculations of quantitative relationships between soils and soil-forming factors. (Reprint from Acta Agriculture Scandinavia. VIII: 3:279-284.) Bibliog. pp. 283-284.
28. LAG, J. 1959. Rendzina-like soils in Norway. Gjovik, 7 pp.
29. MILLER, J. and L.B. LEOPOLD. 1953. The use of soils and paleosols for interpreting geomorphic and climatic history of arid regions. (Communicated paper).

BIBLIOGRAPHY

SOIL MINERALOGY

- In: Desert research. Jerusalem. pp. 453-462.
50. MILJKOVIC, N. et al. 1959. Salt-affected soils of Yugoslavia. *Soil Sci.* 88(1):51-55.
 51. MISRA, S.G. 1958. Production of alkalinity in normal soils with special reference to the formation of potassium soils. *Proc. Nat. Acad. Sci. India.* 28:91-102. Ref.: *Soils and Fertilizers*, 1959, No. 5, ref. 2026.
 52. NEMECEK, J. 1958. Chernozem on fine-textured Pleistocene deposits in North-western Czechoslovakia. *Sborn. Ceskosl. akad. zeměd. ved. rostl. výroba.* 4(6-7):837-848. Bibliog. Summary in Russian.
 53. NEWTON, J.D. et al. 1959. Grey wooded soils and their management. *Bull. Univ. Alberta Fac. Agric.*, 21:88.
 54. Practical applications of engineering soil maps. 1957. By W.W. Holman et al. New Brunswick-New Jersey. XII, 114 pp. (Rutgers univ. The state univ. of New Jersey. Engineering) soil survey of New Jersey. Report No. 22. Eng. res. bull. College of eng. No. 36).
 55. RADET, E. 1958. Propriétés agricoles des sols de craie de la Champagne. *Bull. Assoc. Franc. étude sol.* No. 6:277-303.
 56. SATYANARAYANA, K.V.S. and Y.P. BALI. 1958. Survey and classification of land in the villages Bapraula, Bakarwala and Mundka (Daber Tract), dehli State. 2. *J. Soil and Water Conservat. India.* 7(1):22-26.
 57. SMET, L.A.H. DE. 1959. Pedological reconnaissance map of the peat reclamation districts in Southern Groningen, Drente and Northern Overijssel. *Boor en Spade.* 10:20-26.
 58. Soils of South Australia. 1959. *J. Agric. South Australia.* 63(1):22-28; No. 2:43-48.
 59. STEPHENS, C.C. and C.M. DONALD. 1958. Australian soils and their responses to fertilizers. In: *Advances Agron.* 10:167-256. Bibliog. pp. 253-256.
 60. TAMHANE, R.V. and N.G. NAMJOSHI. 1959. A comparative study of black soils formed from different parent rocks. *J. Indian Soc. Soil Sci.*, 7(1):49-63.
 61. WEBER, N.A. 1959. Isothermal conditions in tropical soil. *Ecology.* 40(1):153-154.
 62. WIJK, C.L. VAN. 1959. Reconnaissance soil survey—east coast New Ireland, Papua and New Guinea *Agric. J.*, II(4): 95-100.
 63. ZONNEVELD, I.S. 1959. Initial soil formation ("ripening") in freshwater sediments. *Boor en Spade.* 10:87-97.
 64. VAKHROMEYEV, S.A. 1959. Instructions on mineragraphy. (Textbook for students of geological-surveying institutes). Translation from Russian. L'vov, Izd-vo L'vovsk. un-ta. 251 pp. with illustr. Bibliog. pp. 246-248. In Ukrainian.
 65. VIKULOVA, M.F. 1960. Investigation of mixed clay minerals. *Dokl. Akad. Nauk SSSR.* 130(1):173-175.
 66. KOTEL'NIKOV, D.D. 1959. Influence of water-soluble salts in clays on the nature of electron microphotographs of clay minerals. *Izv. Akad. Nauk SSSR. Ser. geol.* No. 12:28-35. Bibliog. 11 refs.
 67. Clays and clay minerals. 1959. Proceedings of the 6-th Nation. conference on clays and clay minerals. Berkeley, Calif., Aug. 19-23, 1957. London, 411 pp. (Int. ser. of monographs on earth sci. Vol. 2).
 68. GIESEKING, J.E. 1955. Exchange adsorption by clays of large organic cations. In: *Soil and soil-aggregate stabilization. A symposium.* Washington, pp. 75-81.
 69. GUENNELON, R. 1959. Analyses des silicates d'alumine. (Minéraux argileux). *Ann. Agron., Ser. A.* 10(1):77-98.
 70. KHAN, D.H. 1959. Profile distribution of the sand minerals in some rendzinas, red-brown soils, and terra rossas. *Soil Sci.* 88(2):67-76.
 71. WADA, K. 1959. Reaction of phosphate with allophane and halloysite. *Soil Sci.*, 87(6): 325-330.

PHYSICAL PROPERTIES OF SOILS AND METHODS OF INVESTIGATION

72. AGAYEV, B.M. and R.G. MAMEDOV. 1959. Kinetics of the desiccation of meadow soils in the Karabakh Steppe. *Izv. Akad. Nauk AzerbSSR. Ser. biol. i s.-kh. nauk.* No. 5:11-24. Bibliog. 10 refs. Summary in Azerbaydzhani.
73. AFANAS'YEV, N.I. 1959. Water and physical properties of soils of the upper terrace of the Dnestr River. *Tr. Moldavsk. n.-i. in-ta oroshayemogo zemledeliya i ovoshchevodstva.* Vol. 1:59-69. Bibliog. 5 refs.
74. BOYAROVICH, N.M. 1959. Water regime of light-chestnut clay loam soils in the dry-farming area of the Alma-Ata region. *Vestn. s.-kh. nauki (Alma-Ata).* No. 5: 41-53. Bibliog. 14 refs. Summary in Kazakh.
75. VESELKINA, R.V. 1959. Moisture dynamics in soils of the Lenkoran district of Azerbaydzhani SSR. *Izv. Akad. Nauk AzerbSSR. Ser. biol. i s.-kh. nauk.* No. 5:41-53. Summary in Azerbaydzhani.
76. VOL'KHIN, V.V. and V.L. ZOLOTAVIN.

BIBLIOGRAPHY

1959. Photographic method of recording the process of sedimentation. *Zavodskaya laboratoriya*. 25(12):1532-1533.
77. IL'IN, I. A. 1959. Water resources of the Fergana valley (hydrological outline). Leningrad, Gidrometeoizdat. 247 pp., with illustr. Bibliog. p. 181.
78. KOPYT, A. D. and D. P. ANISTRATENKO. 1959. Problem of the number of samples for soil moisture determinations. *Tr. Kazakhsk. n.-i. gidrometeor. in-ta*. No. 13:89-96. Bibliog. 6 refs.
79. LEBEDEV, A. V. 1959. Certain results of a study of the balance and dynamics of moisture in the aeration zone of the hydrogeological station near Moscow. *Tr. Vsesoyuzn. n.-i. in-ta gidrogeol. i inzh. geologii*. Collection No. 18:42-50, with tables.
80. MAVRITSKIY, B. F. 1959. Principles of ground-water distribution in the Irtysh depression. *Byul. Mosk. o-va ispyt. prirody*. Vol. 64. Otd. geol. 34(4): 97-112, with maps. Bibliog. 13 refs.
81. MUSTAFAYEVA, M. 1959. Determination of water evaporation during sprinkling, using the method of tagged atoms. *Sots. s. kh. Azerbaydzhana*. No. 12:49-50.
82. NIFANTOV, A. P. 1959. Granulometric analysis of clay soils by means of a separatory funnel. *Tr. Vsesoyuzn. n.-i. in-ta. gidrogeol. i inzh. geologii*. Collection No. 18:106-109.
83. NIFANTOV, A. P. Preparation of clayey soils for granulometric analysis. *Ibid.* pp. 93-105. Bibliog. pp. 104-105.
84. ORLOV, D. S. 1959. Light absorption by humic substances in the visible part of the spectrum. *Nauchn. dokl. vyssh. shkoly. Biol. nauki*. No. 4:192-197. Bibliog. pp. 196-197.
85. ROTAR', F. T. 1959. Natural conditions in Moldavia and the control for moisture (from long-period observations by an agronomist). Kishinev, "Kartya molodovenyaske". 151 pp., with illustr. Bibliog. pp. 148-149.
86. SAVCHENKO, S. YE. 1959. Determination of specific weight in salinized soil materials and soils by the volumetric method in kerosene. *Dokl. Akad. Nauk TadzhSSR*. 2(1):19-25. Bibliog. 7 refs. Summary in *Tadzhik*.
87. TULAYKOVA, K. P. 1959. Problem of the role of biogenic calcium in the aggregation of soil particles. *Tr. Ul'yanovsk. s.-kh. in-ta*. 7(1):3-12.
88. FEDOSEYEV, A. P. 1959. Soil moisture in relation to the relief of an area. *Tr. Kazakhsk. n.-i. gidrometeorol. in-ta*. No. 13:66-88. Bibliog. 13 refs.
89. FEDOSEYEV, A. P. Determination of the moisture content of soil in large areas from the depth of wetting. *Ibid.* pp. 45-65, with maps. Bibliog. 6 refs.
90. ANDREWS, R. G. 1959. Hydrology in soil and water conservation. I. *Soil Conservation*. 24(11, 12):239-241; 268-271.
91. BIRRELL, K. S. and R. Q. PACKARD. 1958. Low-temperature adsorption of various gases by soils. Wellington. pp. 70-82. (Soil Bureau publ. No. 135).
92. ESCHNER, A. R. et al. 1957. Physical properties of 134 soils in six Northeastern states. Upper, Darby, Pa., 12:6. (U.S. Dept. agric. Northeastern forest exp. station. Station paper, No. 89).
93. FOX, W. E. and D. S. PAGE-HANIFY. 1959. A method of determining bulk density of soil. *Soil Sci*. 88(3):168-171. Bibliog. pp. 170-171.
94. KAWAGUCHI, K. and H. TORATANI. 1958. Determination of apparent density of soil aggregate by the Kerosene-displacement method. *J. Sci. Soil and Manure. Japan*. 29(8):337-340.
95. LEENHEER, L. DE. 1959. Praktische Probleme und Feldversuche über die Verbesserung der Bodenstruktur und ihre Beurteilung im Felde. *Landwirtsch. Forsch. Sonderh.* 12:41-49.
96. MAINFORT, R. C. 1955. Soil stabilization with resins and chemicals. In: *Soil and soil-aggregate stabilization. A symposium*. Washington. pp. 112-120. Bibliog. pp. 119-120.
97. MAZURAK, A. P. and E. C. CONRAD. 1959. Rates of water entry in the three great soil groups after seven years in grasses and small grains. *Agron. J.* 51(5):264-267. Bibliog. 266-267.
98. MAGY, L. 1958. Change in soil temperature with time and depth. *Hidrologiai közlöny*. 38(6):418-425. Summary in German and English.
99. PHILIP, J. R. 1959. The early stages of absorption and infiltration. *Soil Sci*. 88(2): 91-97.
100. PRIESTLEY, C. H. B. 1959. Heat conduction and temperature profiles in air and soil. *J. Austral. Inst. Agric. Sci.* 25(2):94-107.
101. REMILLON, A. 1955. Stabilization of laterite soils. In: *Soil and soil-aggregate stabilization. A symposium*. Washington. pp. 96-101.
102. RICHARDS, L. A. 1953. Water conducting and retaining properties of soils in relation to irrigation. In: *Desert research*, Jerusalem. pp. 523-546.
103. SHARP, A. L. 1959. *Journal of Soil and Water Conservation*, Vol. 14(2): 77-78.

BIBLIOGRAPHY

104. TOKUBO, K. and A. OKUDA. 1958. Studies on the effect of soil conditioners. Pt. 9. Mechanism of the formation of water stable aggregate of soils (No. 4). J. Sci. Soil and Manure. Japan 29(8):345-348.
 105. WINTERKORN, H. F. 1955. The science of soil stabilization. In: Soil and soil-aggregate stabilization. A symposium. Washington. pp. 1-24. Bibliog. pp. 22-24.
 106. YAWNEY, H. W. 1959. A soil-depth probe for shallow forest soils. J. Forestry, 57(6):435.
- SOIL CHEMISTRY AND METHODS OF ANALYSIS
107. ANTIPOV-KARATAYEV, I. N. 1959. Physicochemical investigations in relation to the reclamation of solonchets. Shortened stenographic report at the 1st All-Union meeting on the reclamation and cultivation of solonchets, June 16-22, 1959, in Stalingrad. Vestn. s.-kh. nauki. No. 12:11-20. Bibliog. 13 refs.
 108. BABENYSHEV, V. M. and A. I. BLESNOVA. 1959. Amperometric titration of magesium with ammonium ferrocyanide. Zh. analit. khimii. 14(6):682-685. Bibliog. 25 refs.
 109. BARANOV, V. I., V. K. KHRISTIANOV, and B. V. KARASEV. 1959. Photoneutronic method for determining the deuterium concentration in natural water. Dokl. Akad. Nauk SSSR. 129(5):1035-1037. Bibliog. 6 refs.
 110. GOREMYKIN, V. E. 1959. Influence of Ca^{++} and Mg^{++} on the sodium function of glass electrodes. Gidrokhim. materialy (Gidrokhim. in-t Akad. Nauk SSSR). Vol. 29:205-210. Bibliog. 7 refs.
 111. DEGTYARENKO, A. P., R. I. LIBINA, and A. D. MILLER. 1959. Concentration of co-precipitation with sulfides and determination of microscopic amounts of Cu, Zn, Pb, Co, Hg, Ag, V, W, and Mo for the analysis of natural water. Gidrokhim. materialy (Gidrokhim. in-t Akad. Nauk SSSR). Vol. 29:248-253. Bibliog. 14 refs.
 112. DOROSH, V. M. 1959. Problem of the precipitation of iron and calcium with barium sulfate. Sb. nauch. tr. (Irkutsk. n.-i. in-t redkikh metallov). No. 8:49-64. Bibliog. 6 refs.
 113. YEREMENKO, V. YA. 1959. Spectrographic determination of microelements (Ni, Co, Cu, V, Sn, Mo, Pb and Mn) in natural waters. Gidrokhim. materialy (Gidrokhim. in-t Akad. Nauk SSSR). Vol. 29:248-253. Bibliog. 11 refs.
 114. ZUL'FUGARLY, D. I., M. I. ABDULAYEVA, and A. I. ABDULAYEV. 1959. Distribution of cobalt in the soils of Azerbaydzhan. Uchen. zap. (Azerbaydzh. un-t). Fiz.-mat. i khim. seriya. No. 4:69-72. Bibliog. 16 refs. Summary in Azerbaydzhan.
 115. Spectrographic determination of microelements in natural waters. (Communication. I) I. T. Klimov and V. Ya. Yermenko. Concentration of Ni, Co, Ag, Cu, V, Sn, Bi, Fe, Pb, and Mn by means of sodium diethyl thiocarbonate. Gidrokhim. materialy (Gidrokhim. in-t Akad. Nauk SSSR). Vol. 29:255-263. Bibliog. 18 refs.
 116. KORCHAGINA, YE. D. 1959. Recent methods of determining microelements in soils and plants. Tr. Staligr. s.-kh. in-ta. 11(1):121-123. Bibliog. 9 refs.
 117. KULESHOV, G. T. 1959. Zinc content in the soils of the Rostov Region. Nauch. dokl. vyssh. shkoly. Biol. nauki. No. 4:202-204.
 118. MILLER, A. D. and R. I. LIBINA. 1959. Concentration with the precipitation of calcium carbonate and determination of a series of microelements in natural waters, water extracts and runoff water. Zh. prikladnoy khimii. 32(12):2624-2631. Bibliog. 13 refs.
 119. MOVSISYAN, YE. M. 1959. Method of studying humus and the results of its application to the soils of the Ararat valley. Yerevan. Izd-vo Glav. upr. s.-kh. nauk. 123 pp., with illustr. Bibliog. pp. 99-103. Part of the text in Armenian.
 120. MURAV'YEVA, N. T., M. I. BRATCHEVA, and N. F. ALEKSEYENKO. 1959. Problem of the oxidation-reduction potential of certain soils in the Kashka-Dar'ya valley. Dokl. Akad. Nauk UzSSR. No. 11:52-56. Summary in Uzbek.
 121. PETERBURGSKIY, A. V. 1959. Exchange ions in soils and their availability to plants (Shortened report at the 1st All-Union delegate meeting of soil scientists and the International conference on the chemistry and fertility of soils in Hamburg). Izv. Timiryazevskoy s.-kh. akad. No. 6:70-76. Bibliog. pp. 75-76.
 122. NECHIPORENKO, G. N. and M. I. KRIVEN-TSOV. 1959. Trilonometric determination of sulfate ions in water when their content is small. Gidrokhim. materialy (Gidrokhim. in-t Akad. Nauk SSSR). Vol. 29:211-213.
 123. ANCELLIN, J. F. et al. 1959. Contribution au l'etude du potassium dans les sols de limon. Compt. rend. Acad. agric. France 45(10):491-499.
 124. AOKI and YAMAMOTO, A. 1958. Studies on the behavior of molybdenum in soil and plant. Pt. I. The molybdenum content of soil and herbage in the area affected by molybdenum poisoning. J. Sci. Soil and Manure, Japan. 29(8):363-367.
 125. AGRINIER, H. 1950. Chromatographie sur papier du molybdene. Application a la determination semiquantitative de cet element dans les mineraux, les roches et les sols.

BIBLIOGRAPHY

- Compt. rend. Acad. Sci. 249(22):2365-2366. Bibliog.
 26. JOHNSTON, H. H. 1959. Soil organic matter. I. Electrophoretic separation of acid-resistant components. Soil Sci. Soc. America Proc., 23(4):293-295.
 27. JORDAN, J. V. and G. O. BECKER. 1959. Sulfur studies in North Idaho soils using radio-sulfur. Soil Science 83(1):1-6. Bibliog. pp. 5-6.
 28. KARRMAN, K. J. et al. 1959. Potentiometric microtitration of potassium. Mikrochimica Acta. No. 5:775-778.
 29. KROLL, W. and B. MEYER. 1959. Die charakterisierung von Humusformen durch Siebanalyse und mikromorphologische Untersuchung am Beispiel einer Bodenserie auf mittlerem Buntsandstein bei Göttingen. Landwirtsch. Forsch. 12(1):12-17.
 30. LINDSAY, W. L. et al. 1959. Determination of aluminum ion activity in soil extracts. Soil Sci. Soc. America Proc. 23(4):266-269.
 31. McKENZIE, R. M. 1959. Trace elements in some South Australian terra rossa and rendzina soils. Austral. J. Agric. Res. 10(1):52-57.
 32. MISTERSKI, W. and W. LOGINOW. 1959. Study of certain physicochemical properties of humic acids. Sbor. Ceskoslov. akad. zemed. ved. Rostl. vyroba. 5(4):457-478. Bibliog. pp. 475-476. Summary in Russian.
 33. NELSON, L. E. 1959. A comparison of several methods for evaluating the potassium status of some Mississippi soils. Soil Sci. Soc. America Proc. 23(4):313.
 34. PAVEL, L. 1959. Formation of soluble intracomplex metal compounds with a dark-colored fraction of fulvic acids from peat. Sborn. Ceskoslov. akad. zemed. ved. rostl. vyroba. 5(5):639-650. Bibliog. pp. 649-650. Summary in Russian.
 35. SIEGEL, O. 1959. Ueber den Gehalt der Böden der Bundesrepublik Deutschland an Strontium⁹⁰ und Radium²²⁶. Landwirtsch. Forsch. Sonderht 12:22.
 36. SOWDEN, F. J. 1959. Investigations on the amounts of hexosamines found in various soils and methods for their determination. Soil Sci. 88(3):138-143.
 37. SPENCER, K. 1958. Phosphorus in soils of the Murrumbidgee irrigation areas. New South Wales. 2. The accumulation of phosphatic residues. Melbourne. 18 pp. Bibliog. pp. 17-18.
 38. YUAN, T. L. 1959. Determination of exchangeable hydrogen in soils by a titration method. Soil Sci. 88(3):164-167.
 39. YUAN, T. L. and J. G. A. FISKELL. 1959. Aluminum studies. 2. The extraction of aluminum from some Florida soils. Soil Sci. Soc. America Proc. 23(3):202-205.
 40. ZECUW, D. DE. 1959. Radioactive contamination of soil and plants. Kernergie in de Landbouw. 1:10-11.
 41. ZIECHMANN, W. and G. PAWELKE. 1959. Zur Methodik der Huminsäureuntersuchung. Landwirtsch. Forsch. 12(1):17-20.
- ## SOIL BIOLOGY AND MICROBIOLOGY
42. BABAK, N. M. 1959. Distribution of the Azotobacter in certain soils of Moldavia. Tr. Moldavsk. n.-i. in-ta oroshayemogo zemledeliya i ovoshchevodstva. Vol. 1: 277-289, with maps. Bibliog. 10 refs.
 43. BLINKOV, G. N. and A. N. NOVOSELOVA. 1959. The Azotobacter of podzolic soils of Siberia. Mikrobiologiya. 28(6):911-915. Bibliog. pp. 914-915.
 44. BUYANOVSKIY, G. A. 1959. Sulfate-reducing bacteria in certain meadow soils of the Kura-Araks lowland. Dokl. (Akad. Nauk AzerbSSR). 15(10):949-953. Summary in Azerbaydzhan.
 45. ZHUKOVA, R. A. 1959. Toxicity of soils in the Kola Peninsula for aerobic cellulose bacteria. Mikrobiologiya. 28(6):904-910, with tables. Bibliog. p. 910.
 46. ZHUKOVA, R. A. 1959. Cellulose-decomposing activity of aerobic and cellulose bacteria in relation to the toxicity of soils in the Kola Peninsula. (Author's dissertation for a candidate's degree in biological sciences, Institute of Microbiology, Academy of Sciences of the USSR). Moscow. 21 pp.
 47. IVANOVA, A. A. 1959. Influence of the depth of plowing of the grass sod on microbiological processes in light chernozem of the Vakhsh valley. Dokl. Akad. Nauk TadzhSSR. 2(4):31-38. Summary in Tadzhik.
 48. PEREL', T. S. 1959. Earthworms as indicators of soils conditions in forest plantations. Author's dissertation for a candidate's degree in biological sciences. (Moscow State pedagogical Institute im. V. I. Lenina). Moscow. 14 pp.
 49. PROSTAKOV, P. YE. 1959. Methods of regulating nitrification in chernozems of the Caucasus region during irrigation. Tr. Stalingr. s.-kh. in-ta. Vol. XI, Vyp. 1, No. 12:129-143. Bibliog. 27 refs.
 50. SYROYECHKOVSKIY, YE. YE. 1959. Role of animals in the formation of primary soils under the conditions of the Polar regions of the world (as exemplified by Antarctica). Zool. zh. 38(12):1770-1775.
 51. BECKING, J. H. 1959. Nitrogen-fixing bacteria of the genus Beijerinckia in South African soils. Plant and Soil. 11(3):193-

- 206.
152. BIRCH, H. F. 1959. Further observations on humus decomposition and nitrification. *Plant and Soil*. II(3):262-286.
 153. BURGESS, A. 1958. Microorganisms in the soil. London. 188 pp.
 154. CASIDA, L. E. 1959. Phosphatase activity of some common soil fungi. *Soil Sci.* 87 (6):305-310. Bibliog. pp. 309-310.
 155. DEASON, T. R. 1959. Three chlorophyceae from Alabama soil. *Amer. J. Bot.* 46(8): 572-578. Bibliog. 12 refs.
 156. GELCEROVÁ, F. J. 1959. Importance of bacteria and fungi in the formation of humus. *Sborn. Českosl. akad. zeměd. ved. rostl. výroba*. Vol. 5:603-612.
 157. JONES, P. C. T. 1955. Microbiological factors in soil stabilization. In: *Soil and soil-aggregate stabilization. A symposium*. Washington. pp. 81-95.
 158. IVARSON, K. C. and F. J. SOWDEN. 1959. Decomposition of forest litters. I. Production of ammonia and nitrate nitrogen, changes in microbial population and rate of decomposition. *Plant and Soil*, II(3): 237-248.
 159. LOUW, H. A. and D. M. WEBLEY. A plate method for estimating the numbers of phosphate-dissolving and acid-producing bacteria in soil. *Nature*. 182(4645):1317-1318.
 160. Manual of microbiological methods. 1957. N. Y. -London. 315 pp.
 161. MARTON, M. and I. SZABO. 1959. *Nocardia uniformis*, a new species from solonetz soil. *Acta Microbiol.* 6(2):131-134. Bibliog. 8 refs.
 162. NORMEN, JAMES. 1959. Plate counts of bacteria and fungi in a saline soil. *Canad. J. Microbiol.* 5(5):431-440. Bibliog. 9 refs.
 163. NOVAK, B. B. 1958. Green manure from the microbiological point of view. *Sborn. Českosl. akad. zeměd. ved. rostl. výroba*. 4(6-7):791-798. Bibliog. pp. 797-798. Summary in Russian.
 164. NOWAK, W. 1959. Neure Ergebnisse des Directnachweises von Bacterien im Boden mittels der kombinierten Aufwuchs-Fluorochromierungsmethode. (Summary). *Ztb. Bakteriell., Parasitenkunde, Infektionskrankh. und Hyg.* 176(3/6):243-244.
 165. PAPAIVIZAS, G. C. and CH. B. DAVEY. 1959. Evaluation of various media and antimicrobial agents for isolation of soil fungi. *Soil Sci.* 83(2):112-117.
 166. ROBINSON, J. B. and C. T. COPKE. 1959. Preliminary studies on the distribution of actinophages in soil. *Canadian Journal of Microbiol.* 5(5):479-484.
 167. SOWDEN, F. J. and K. C. IVARSON. 1959. Decomposition of forest litters. 2. Charges in the nitrogenous constituents. *Plant and Soil*. II(3):249-261.
 168. STEVENSON, I. L. 1959. Dehydrogenase activity in soils. *Canad. J. Microbiol.* 5(2):229-236. Bibliog. 10 refs.
 169. STUNDL, K. 1959. Zur Frage der Einfluss von Treibstoffen auf die Abbauleistung von Bodenbakterien. (Summary). *Ztb. Bakteriell., Parasitenkunde, Infektionskrankh. und Hyg.*, 176(3/6):244-245.
 170. THORNTON, H. G. 1953. Some problems presented by the microbiology of arid soils. In: *Desert research*. Jerusalem, pp. 295-301.
 171. TOLMSOFF, W. J. 1959. The isolation of nematode trapping fungi from Oregon soils. *Abstr. Phytopathology*. 49:113.
 172. VARGUES, H. 1953. Etude microbiologique de quelques sols sahariens en relation avec la presence d'*Anabasis areticides* Coss. et Moq. (Communicated paper). In: *Desert research*. Jerusalem. pp. 318-324.
- SOIL FERTILITY, FERTILIZERS, AND
TILLAGE
173. AKINDINOV, I. S. 1960. Methods of cultivating black fallow in the zone of deficient humidification. *Zemledeliye*. No. 1:84-88.
 174. ARUTYUNYAN, A. S. 1959. Available P_2O_5 of superphosphate applied together with manure. (Problem of the phosphorus nutrition of vineyards). *Agrobiologiya*. No. 6:936-938.
 175. ASMAYEV, L. R. 1959. Natural fertility of soils in the Oka River flood plain. *Nauch. dokl. vyssh. shkoly. Bibl. nauki*. No. 4: 182-186.
 176. ASROROV, M. T. 1959. Methods of creating a thick uniform plowed layer on irrigated sierozem-meadow soils of the Gissar valley of the Tadzhik SSR. *Izv. Otd. yestestv. nauk (Akad. Nauk Tadzhik SSR)*. No. 2:79-100, with tables. Bibliog. p. 99. Summary in Tadzhik.
 177. AFANAS'YEV, D. YA. 1959. Flood-plain meadows of the Poles'ye Dnepr, their improvement and rational utilization. (Akad. Nauk SSSR, In-t botaniki). Kiev. *Izd-vo Akad. Nauk SSSR*. 272 pp., with illustr. Bibliog. pp. 263-270. In Ukrainian.
 178. BAL'KOV, V. F. and S. F. NEGOVELOV. 1959. Suitability of soils in the foothills of the Krasnodar region for fruit orchards. *Uchen. zap. (Krasnodarskiy ped. in-t)*. No. 24:130-139. Bibliog. 5 refs.
 179. VAN'KOVICH, G. 1959. Comparative evaluation of methods of basic soil tillage in

BIBLIOGRAPHY

- Moldavia. Zemledeliye i zhivotnovodstvo Moldavii. No. 11:20-23.
0. VITOVITSKIY, M. M. 1959. New methods of cultivating soil under crop rotation in Kirgizia. Zemledeliye. No. 12:78-79.
1. VLASYUK, P. A. and YE. S. KOSMATYY. 1959. Method of tagging atoms in agricultural physiology. Kiev. Izd-vo Ukr. akad. s.-kh. nauk. 327 pp., with illustr. Bibliog. pp. 322-324.
2. MOLDOVA, R. V. 1959. Influence of various methods of soil tillage on the structure and hydrophysical properties of chestnut soil. Tr. Staligr. s.-kh. in-ta. 11(1):169-177.
3. GALKIN, V. S. 1959. Complete chemistry of flood-plain soils in the kolkhozes of the Central Akhtubia district. Tr. Staligr. s.-kh. in-ta. 11(1):107-111.
4. GALUZA, O. I. 1959. Chemical characteristics of peats on the left bank of the Ob' River and their agricultural utilization. Byul. opyt. i n.-i. rabot Ubinsk. op. meliorat. stantsii. No. 5:5-17. Bibliog. 84 refs.
5. GONTAREVA, N. V. 1959. Dynamics of nutrients assimilated by plants in soil depending on the system of soil tillage and fertilization. Tr. Moldavsk. n.-i. in-ta oroshayemogo zemledeliya i ovoshchevodstva. Vol. 1:255-276. Bibliog. 6 refs.
- GANTIMUROV, N. I. 1959. Effectiveness of fertilizers on peat-bog soils under conditions prevailing in Central Baraba. Byul. opyt. i n.-i. rabot Ubinsk. op. meliorat. st. No. 5:62-77. Bibliog. 5 refs.
- GOL'FAND, B. 1959. Improvement of the phosphate regime of soils in rice fields in the lower reaches of the Kuban' River. S. kh. Sev. Kavkaza. No. 9:84-85.
- GORDEYEVA, YE. A. 1959. Mobilization of nitrogen in the peat-bog soils of Baraba during their agricultural reclamation. Byul. opyt. i n.-i. rabot Ubinsk. op. meliorat. st. No. 5:49-51. Bibliog. 6 refs.
- GRINSHIN, P. V. 1959. Influence of an increased amount of adsorbed magnesium on soil properties. Nauch. dokl. vyssh. shkoly. Bibl. nauki. No. 4:198-201. Bibliog. 6 refs.
- GYUL'AKHMEDOV, A. 1959. Effectiveness of the method and time of application of microelements to cotton. Sots. s. kh. Azerbaydzhana. No. 10:15-17.
- DOKUCHAYEV, N. S. 1959. Certain results of experiments on methods of soil tillage and the application of fertilizers to solonchets under winter rye and oat. Byul. opyt. i n.-i. rabot Ubinsk. op. meliorat. st. No. 5:18-26.
- DOSPEKHOV, B. A., and V. M. BOGOLYUBOVA. 1959. Influence of various methods of basic tillage on the aerophysical properties of soil and yield. Izv. Timiryazevskoy s.-kh. akad. No. 6:57-69, with tables. Bibliog. pp. 68-69.
193. IVANOV, P. K., and V. A. POTUSHANSKIY. 1959. Certain results of the study of the soil tillage method of T. S. Mal'tsev in the Ul'yanov Region. Tr. Ul'yanovsk. s.-kh. in-ta. 7(1):55-65.
194. KAZIYEV, M. Z., and L. A. PANFILOVA. 1959. Influence of soil salinization on the uptake of phosphorus by cotton. S. kh. Uzbekistana. No. 12:22-24.
195. KALINOVSKIY, A. V. 1959. Accumulation and decomposition of the plant residue of perennial grass and their influence on the composition and properties of soil. Tr. Belorussk. s.-kh. akad. Vol. 31:48-65. Bibliog. 13 refs.
196. KANIVETS, I. I. 1959. Selection and evaluation of land for fruit growing. Sadovodstvo, vinogradarstvo i vinodeliye Moldavii. No. 6:24-28.
197. KOMAREVSKAYA, V. P., A. G. KUZ'MINA, and V. D. LUZGINA. 1959. Effectiveness of the use of ammonia water in the kolkhozes of the Alar district. Tr. Vost.-Sib. filiala (Akad. Nauk SSSR). No. 29:78-84.
198. KONUROV, S. G. 1959. Problem of the study of the dynamics of the fertility of light-chestnut soils under various field crops. Tr. Staligr. s.-kh. in-ta. 11(1):145-158. Bibliog. 5 refs.
199. KURGUL'TSEVA, L. I. 1959. Influence of aeration on the rate of water entry into the root system of cotton. Dokl. Akad. Nauk UzbSSR. No. 11:48-51. (Summary in Uzbek).
200. MALEINA, A. A. 1959. Application of the method of tagged atoms for the study of available phosphates. Author's dissertation for a candidate's degree in agricultural sciences (Scientific institute of fertilization and insecticides). Moscow. 18 pp.
201. MEDVEDEV, B. A. 1959. Grouping of soils according to their agricultural productivity. BSSR. Tr. Belorussk. s.-kh. akad. Vol. 31:31-47.
202. Methodology of field experimentation. (Collection of articles). Edited by P. G. Naydin. Moscow, Sel'khozgiz. 318 pp., with illustr.
203. NOVAK, A. G. 1959. Major problems of agriculture in the Far East. 2d revised and enlarged edition. Khabarovsk. kn. izd. 448 pp., with illustr. Bibliog. pp. 437-447.
204. PANENKO, I. D. 1959. Short results of investigations on sprinkling irrigation of agricultural crops in Moldavia. Tr. Moldavsk. n.-i. in-ta oroshayemogo zemled-

- eliya i ovoshchevodstva. Vol. 1:5-24. Bibliog. 7 refs.
205. PETRUKHINA, V.M. 1959. Change in the calcium and phosphorus content in forage crops in the Tatar ASSR as dependent on differences in soil and the phase of plant development. Author's summary of his dissertation for a candidate's degree in agricultural sciences (Veterinary Institute of Kazan'). Kazan'. 15 pp.
 206. PROKOPENKO, D.D. 1959. Investigation of the process of harrowing at high speeds. Vestn. s.-kh. nauki. No. 12:94-99.
 207. RADOV, A.S. 1959. Experiments in the use of fertilizers under conditions prevailing in the Stalingrad Region. Tr. Stalingr. s.-kh. in-ta. 11(1):95-106.
 208. RADOV, A.S. State and development of agricultural chemistry in the People's Republic of Albania. (From personal impressions gained during a trip in 1957). Ibid. pp. 87-94.
 209. FROLOV, S.S., and L.I. POKROVSKIY. 1959. Use of high polymers for increasing the fertility of soils. Priroda. No.12: 86-87.
 210. ALARIE, A. 1959. Biologie des sols et fertilite. Pt. 1-3. Agriculture (Quebec). 16(3):83-85, 96; No. 4:104-105; No. 5:157-160. Bibliog. 17 refs.
 211. ALLISON, F.E. et al. 1959. Soil fertility studies in lysimeters containing lakeland sand. Washington. 62 pp. (Techn. Bull. No. 1199, U.S. Dept. Agric.).
 212. ARAKERI, H.R. et al. 1959. Soil management in India. Bombay. 584 pp.
 213. BOERNER, H. et al. 1959. Experimentelle Untersuchungen zum Problem der Bodenmüdigkeit am Beispiel von Lein und Roggen. Z. Pflanzenbau und Pflanzenschutz. 66(11-12):691-703.
 214. BOULDIN, D.R. and E.C. SAMPLE. 1959. Calcium phosphate fertilizers. 3. The effect of surface area on the availability coefficients of the dicalcium phosphates. 4. The relation between solubility in soils and availability coefficients of dicalcium and fused tricalcium phosphates. Soil Sci. Soc. America Proc. 23(4):276-285.
 215. BURRIS, R.H. 1959. Nitrogen nutrition. Annual Rev. Plant Physiol. Vol. 10:323-328.
 216. CHAMINADE, R. 1959. La fumure minerale en terre irriguee. Rev. agric. Afrique Nord. 57(2097):820-821.
 217. COOKE, G.W. 1958. Soils and fertilizers. J. Roy. agric. Soc. England. Vol. 119:105-122. Bibliog. 34 refs.
 218. COOPER, R. 1959. Bacterial fertilizers in the Soviet Union. Soils and Fertilizers. 22(5):327-333.
 219. DELOYE, M. and H. REBOUR. 1958. La conservation de la fertilite des sols. 3d ed. Paris, 164 pp.
 220. DHAR, N.R. 1959. Land fertility improvement. J. Indian Soc. Soil Sci. 7(1):1-25.
 221. DOBRZANSKI, B. 1959. Einfluss der Düngung auf den Humusgehalt des Bodens. Z. Pflanzenernähr., Düng., Bodenkunde, 84(129):(1-3):122-127.
 222. DUCHAUFOR, PH. and M. BONNEAU. 1959. Une methode nouvelle de dosage du phosphore assimilable dans les sols forestiers. Bull. Assoc. Franc etude sol. No. 4:193-198.
 223. ISLAM, M.A. and R.A. HAFIZAR. 1959. Degree of phosphate saturation of soils as a measure of phosphate availability for plants. Soil Sci. 88(3):172-178.
 224. FAUSER, O. 1959. Kulturtechnische Bodenverbesserung. I. Allgemeines, Entwässerung. Berling. 127 pp.
 225. FEUERLEIN, W. 1959. Trockenheit und Bodenbearbeitung. Mitt. Dtsch. Landwirtschafts Ges. 74(49):1423-1424.
 226. FLOCKER, W.J. 1959. Winter cover crop help fight soil compaction. Crops and Soils. 12(1):413-414.
 227. GROSSI, F.X. and J.L. WOOLSEY. 1955. Effect of fatty quaternary ammonium salts on physical properties of certain soils. J. and Engng Chem. 47(11):2253-2258.
 228. HAFENRICHTER, A.L. 1958. New grasses and legumes for soil and water conservation. In: Advances in agronomy, Vol. 10:349-406. Bibliog. pp. 401-406.
 229. HASLBACH, J. 1958. Determination of the wilting point of plants on certain soil groups. Sborn. Ceskosl. akad. zemed. ved. rostl. vyroba. 4(6-7):649-660. Bibliog. (Summary in Russian).
 230. HOFFMAN, W. and K. STEINFATT. 1959. Vergleichende Untersuchungen über die Löslichkeit der pflanzenaufnehmbaren Nährstoffe Kali und Phosphorsäure in frischen und Lufttrockenen stark humosen und organogenen Böden. Landwirtschaft. Forsch. 12(2):77-87.
 231. JORDAN, H.V. and L.E. ENSMINGER. 1958. The role of sulfur in soil fertility. In: Advances Agron. Vol. 10:407-434. Bibliog. pp. 432-434.
 232. LOBB, W.R. and R.L. BENNETTS. 1959. Fertilizer responses on plain soils of Canterbury N.Z. J. Agric. 99(4):317-329.
 233. MAURER, T.C. 1959. Perennial grass residues rescue tired soils. Crops and Soils. 12(2):16-17.
 234. McCLUNG, A.C. et al. 1959. Analyses of several Brazilian soils in relation to plant responses to sulfur. Soil Sci. Soc. Am.

BIBLIOGRAPHY

- Proc. 23(3):221-224.
5. NIESCHLAG, F. 1959. Ergebnisse eines 20 jährigen Kalidüngungsversuches auf humosem Sand. Landwirtsch. Forsch. 12 (2):87-97.
 6. OZANNE, P.G. 1958. Chlorine deficiency in soils. Nature. 182(464): 1172-1173.
 7. RENAULT, R. 1958. Chimie agricole. Vol. 2. La biosphere. Paris. 550 pp.
 8. SAUNDERS, W.M.H. 1959. Effect of phosphate topdressing on a soil from andesitic volcanic ash. I. Forms of soil phosphorus and a method for their determination. N. Z. J. Agric. Res. 2:427-444.
 9. SCHOLL, W. et al. 1959. Fertilizer and plant nutrient consumption: 1957-1958. Farm chemicals. 122(10):66-74.
 10. Soil management and fertilizers. 1958. Rep. division Agricul., July 1, 1957, through June 30, 1958. Iowa, pp. 41-48.
 11. UHRECKY, I. 1957. Preliminary experiments in the study of the effect of legume-grass mixtures on the formation of soil structure. Sborn. vysoke skoly zemed. a lesnicke v Brne. Ser. A. No. 4:497-516. Bibliog. pp. 514-515. Summary in Russian.
- ## SOIL MELIORATION
- GANTIMUROV, I.I. 1959. Main results of the work conducted by the Ubin experimental melioration station. Byul. opyt. i n.-i. rabot Ubinsk. op. meliorat. st. No. 5:5-17. Bibliog. 84 refs.
 - GANTIMUROV, I.I. 1959. Characteristics of the reclamation of saline bogs in Baraba. Byul. opyt. meliorat. st. No. 5:39-48. Bibliog. 19 refs.
 - GURINA, P.N. 1959. Meliorative importance of drainage in the Fergana valley. S. kh. Uzbekistana. No. 12:35-38.
 - LOPATIN, V.D. 1959. Outlook for the increase of plant yield by oxygen melioration of irrigated soils without drainage. Botan. zh. 44(11):1673-1676. Bibliog. p. 1676.
 - MINAYEV, I.V. 1959. Regulation of the water regime of lands being drained by pumping. Tr. Mosk. in-ta inzhenerov zemleustroystva. No. 8:159-164. Bibliog. 7 refs.
 - MOZHEYKO, I.A. 1959. Problem of the reclamation of small rivers in the Moldavian SSR. Tr. Moldavsk. n.-i. in-ta oroshayemogo zemledeliya i ovoshevodstva. Vol. 1:25-36. Bibliog. 5 refs.
 - KOLLA KOV, V.V. 1959. Influence of water supply and leaching irrigation on the water regime and evaporability of soil materials of the Sivash region. Izv. Timiryazevskoy s.-kh. akad. No. 6:107-128, with maps. Bibliog. 8 refs.
 249. KOCHERGA, F.K. 1959. Investigations, planning and conduct of mountain reclamation work in Central Asia. Tr. Sredneaziatsk. n.-i. in-ta lesnogo kh.-va No. 7 (Uzb. akad. s.-kh.). Tashkent. 250 pp., with illustr. and maps. Bibliog. pp. 237-247.
 250. BARLEY, K.P. and A.L. TISDALL. 1959. Effects of flood irrigation and plant growth on two riverine soils. Austral. J. Agric. Res. 10(4):510-517.
 251. BOOY, A.H. 1959. Reclaimed peat moor soils of Drente uniform soils? Boor en Spade, 10:97-105.
 252. BUSCH, C.D. and T.W. EDMINSTER. 1959. Modernizing drainage methods. Soil Conservation. 24(6):133-133.
 253. CAZACU, E. 1959. Problems of the study of the meliorative work in the Rumanian National Republic. Probl. agric. 12:26-34.
 254. DONNAN, W.W. 1959. Field experiences in measuring hydraulic conductivity for drainage design. A symposium. Agric. Engng. 40(5):270-273, 280.
 255. Drainage of agricultural lands. 1957. Madison. 620 pp. Bibliog. pp. 579-611. (Agronomy A. ser. of monographs. Vol. 7).
 256. GROENEWEGER, H. 1959. Relation between chloride accumulation and soil permeability in the Mirrool irrigation area. New South Wales. Soil Sci. 87(5):283-288.
 257. HORTH, C.J. and R.O. FRENCH. 1959. Irrigation queries and the answers. Agric. Gaz. of N.S. Wales. 70(2):75-82.
 258. KALISVAART, I.C. 1958. Subirrigation in the Zuiderzee polders. Wageningen, 55 pp. (Int. Inst. for land reclamation and improvement. Publ. 2).
 259. MARR, J.C. 1958. Border method of irrigation. California. 23 pp. (Calif. Agric. Exp. Stat.).
 260. PESSI, Y. 1958. On the influence of bog draining upon thermal conditions in the soil and in the air near the ground. Acta agric. scand. 8(4):359-374. Bibliog. pp. 373-374.
 261. ROBINS, J.S. 1959. Conducting successful irrigation research. Soil Sci. Soc. America Proc. 23(3):249-50.
 262. SEVENSON, I.L. 1959. Land forming for drainage. The practice of smoothing and shaping land to facilitate the removal of excess rainfall. Agric. Engng, 40(4):208-209, 213.
 263. SPICKA, A. 1958. Influence of various amounts of irrigation on the yield of field and meadow-crops and on the physical properties of soils. Sb. Ceskosl. akad.

BIBLIOGRAPHY

zeméd. ved. rostl. výroba. 4(6-7):775-790. (Summary in Russian.)

SOIL EROSION AND ITS CONTROL

264. BOROVSKIY, V.M. 1959. Soil erosion in Kazakhstan. Vestn. Akad. Nauk KazSSR. No. 11:15-20. (Summary in Kazakh).
265. BUSHINSKIY, V.P., and I.P. GRECHIN. 1959. Problem of soil erosion control on excessively moist soils. S. kh. Sev.-Zap. zony. No. 12:26-28.
266. GORBUNOV, I., V. FEDOTOV, and V. SLASTIKHIN. 1959. Soil erosion and its control. Kishinev, "Kartya Moldovenyaske". 87 pp., with illustr. (In Moldavian).
267. YEVTSIKHEVICH, V.N. 1959. Water erosion in the area of the Khabarovsk district. Amurskiy sb. 1:69-78.
268. ZAYTSEV, V.T. 1959. The importance of forest belts in erosion control in Moldavia. Lesnoye khozyaystvo. No. 12: 71-72.
269. Instructions on methods of soil erosion control and the control of flash floods in the mountain and foot-hill zones of the Azerbaydzhan SSR. (Akad. Nauk AzSSR, Pochv. erozion. stantsiya). Izd-vo Akad. Nauk AzerbSSR. 21 pp., with illustr. and maps. (In Azerbaydzhan).
270. SOBOLEV, S.S. 1959. Soil erosion control. Moscow. Izd-vo M-va s. kh. (Vystavka dostizheniy nar. kh-va SSR). 1 folded leaf containing 12 pp. with illustr.
271. SURMACH, G.P. 1959. Erosion processes in the Kuybyshev Volga region and their control. S. kh. Povolzh'ya. No. 11:46-51.
272. TUGUTOV, R.F. 1959. Control of sand and problems of the conservation of nature. Tr. Kyakhtinsk. muzeya krayevedeniya i Kyakhtinsk. otd. Geogr. o-va SSSR. 17(1): 114-116.
273. SHAKIROV, F.KH. 1959. Erosion in the forest. Priroda. No. 12:114-115.
274. SHCHERBAKOVA, M.V. 1959. Formation of ravines and their control. (O-vo po raspr. polit. i nauchn. znaniy USSR). Kiev. 28 pp. (In Ukrainian).
275. CHEPIL, W.S. 1959. Wind erodibility of farm fields. J. Soil and Water Conserv. 14(5):214-219.
276. FOURNIER, F. 1959. Etude de la relation entre l'erosion du sol par l'eau et es precipitations atmospheriques. C. r. Hebd. Seanc. Acad. Agric. France 15(9): 418-419.
277. GLANDER, W. 1956. Bodenerosion und ihre Bekämpfung. Berlin. 163 pp. Bibli. pp. 161-163.
278. GRAIG, P.G. 1959. Control of wind erosion in the great plains. J. Soil and Water Conservat. 14(4):147-151.
279. HELD, R.B. and J.F. TIMMONS. 1958. Soil erosion control in process in Western Iowa. Ames, Iowa. pp. 295-315. (Iowa State College. Research bull. 460).
280. KANEKO, R. 1958. A statistical investigation of soil erosion. J. Agric. Engng. Soc. Japan, 26(2):1-7.
281. NAGY, I.V. 1959. New results of the study of the erosion of the shores of water reservoirs. Hidrologiai Közlöny. 39(1): 37-47. (Summary in Russian).
282. SINGG, A.W. and V.L. HAUSER. 1959. Terrace benching to save potential runoff from semiarid land. Agron. J. 51(5):289-292.

AIBS Russian Monograph Translations

The AIBS is in the process of expanding its Russian Translations Program extensively. Funds to subsidize translation and publication of important Russian literature in biology have been obtained from the National Science Foundation, as part of a larger program to encourage the exchange of scientific information between the two countries. The following monographs have been published:

Origins of Angiospermous Plants. *By A. L. Takhtajan*

Edited by G. Ledyard Stebbins. Translated by Olga H. Gankin

68 pp. [13 illustrations] 8½ x 10¾. \$3.00, individuals and industrial libraries (U.S. & Canada); \$2.00, AIBS members and all other libraries; \$.50 additional, foreign.

Essays on the Evolutionary Morphology of Plants. *By A. L. Takhtajan*

Edited by G. Ledyard Stebbins. Translated by Olga H. Gankin

144 pp. [32 illustrations] 8½ x 10¾. \$5.00, individuals and industrial libraries (U.S. & Canada); \$4.00, AIBS members and all other libraries; \$.50, additional, foreign.

Problems in the Classification of Antagonists of Actinomycetes. *By G. F. Gause*

Edited by David Gottlieb. Translated by Fritz Danga

165 pp. [18 illustrations] 7 x 10. \$5.00, individuals and industrial libraries (U.S. & Canada); \$4.00, AIBS members and all other libraries; \$.50, additional, foreign.

Arachnida. Vol. IV, No. 2. Fauna of the U.S.S.R. *By B. I. Pomerantzev*

Edited by George Anastos. Translated by Alena Elbl.

199 pp. [638 illustrations] 7 x 10. \$10.00, individuals and industrial libraries (U.S. & Canada); \$9.00, AIBS members and all other libraries; \$1.00, additional, foreign.

Arachnoidea. Vol. VI, No. 1. Fauna of the U.S.S.R. *By A. A. Zachvatkin*

Translated and edited by A. Ratcliffe and A. M. Hughes

567 pp. [705 illustrations] 7 x 10. \$10.00, individuals and industrial libraries; (U.S. & Canada); \$9.00, AIBS members and all other libraries; \$1.00, additional, foreign.

Marine Biology. Trudy Institute of Oceanology. Vol. XX. *Edited by B. N. Nikitin*

302 pp. [66 illustrations] 8½ x 10¾. \$10.00, individuals and industrial libraries; (U.S. & Canada); \$7.50, AIBS members and all other libraries; \$1.00, additional, foreign.

Plants and Xrays. *By L. P. Breslavets*

Editor of English Edition: Arnold H. Sparrow

115 pp. [26 illustrations] 7 x 10. \$5.00, individuals and industrial libraries (U.S. & Canada); \$4.00, AIBS members and all other libraries; \$.50, additional, foreign.

Wintering of Plants. *By I. M. Vasil'yev*

Editor of English edition: Jacob Levitt.

\$9.00, individuals and industrial libraries (U.S. & Canada); \$8.00, AIBS members and all other libraries; \$.50, additional, foreign.

For orders and a FREE copy of our Publications Catalog listing all AIBS Publications, write to:

AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES

2000 P Street, N.W.

Washington 6, D.C.

TRANSLATIONS OF RUSSIAN BIOLOGICAL JOURNALS

The American Institute of Biological Sciences, under a grant from the National Science Foundation, is currently translating and publishing seven Russian research journals in biology.

DOKLADY: BIOLOGICAL SCIENCES SECTION

6 issues per year. First issues published: 1957, Vols. 112-117. Current issues published: 1960, Vols. 130-135.

Subscriptions:

\$20.00 per year, individuals and industrial libraries (U.S.A. & Canada)	\$2.50 additional to each price, foreign
\$15.00 per year, AIBS members and all other libraries	\$4.00 each, single copies

DOKLADY: BOTANICAL SCIENCES SECTION

6 issues per year. First issues published: 1957, Vols. 112-117. Current issues published: 1960, Vols. 130-135.

Subscriptions:

\$7.50 per year, individuals and industrial libraries (U.S.A. & Canada)	\$1.50 additional to each price, foreign
\$5.75 per year, AIBS members and all other libraries	\$1.50 each, single copies

DOKLADY: BIOCHEMISTRY SECTION

6 issues per year. First issues published: 1957, Vols. 112-117. Current issues published: 1960, Vols. 130-135.

Subscriptions:

\$15.00 per year, individuals and industrial libraries (U.S.A. & Canada)	\$3.00 additional to each price, foreign
\$10.00 per year, AIBS members and all other libraries	\$4.50 each, single copies

PLANT PHYSIOLOGY • FIZIOLOGIYA RASTENIY

6 issues per year. First issues published: 1957, Vol. 4, Nos. 1-6. Current issues published: 1960, Vol. 7, Nos. 1-6.

Subscriptions:

\$15.00 per year, individuals and industrial libraries (U.S.A. & Canada)	\$2.00 additional to each price, foreign
\$11.00 per year, AIBS members and all other libraries	\$3.00 each, single copies

MICROBIOLOGY • MIKROBIOLOGIYA

6 issues per year. First issues published: 1957, Vol. 26, Nos. 1-6. Current issues published: 1960, Vol. 29, Nos. 1-6.

Subscriptions:

\$20.00 per year, individuals and industrial libraries (U.S.A. & Canada)	\$2.50 additional to each price, foreign
\$15.00 per year, AIBS members and all other libraries	\$4.00 each, single copies

SOVIET SOIL SCIENCE • POCHVOVEDENIYE

12 issues per year. First issues published: 1958. Current issues published: Jan.-Dec., 1959.

Subscriptions:

\$40.00 per year, individuals and industrial libraries (U.S.A. & Canada)	\$3.00 additional to each price, foreign
\$20.00 per year, AIBS members and all other libraries	\$4.50 each, single copies

ENTOMOLOGICAL REVIEW

ENTOMOLOGICHESKOYE OBOZRENIYE

4 issues per year. First issues published: 1958. Current issues published: 1960, Vol. 39, Nos. 1-4.

Subscriptions:

\$25.00 per year, individuals and industrial libraries (U.S.A. & Canada)	\$3.00 additional to each price, foreign
\$12.00 per year, AIBS members and all other libraries	\$7.50 each, single copies

Order from:

AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES
2000 P Street, N.W. Washington 6, D.C.